

TRANSMITTAL LETTER TO THE UNITED STATES  
DESIGNATED/ELECTED OFFICE (DO/EO/US)  
CONCERNING A FILING UNDER 35 U.S.C. 371

206338US2PCT

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR

09/830851

INTERNATIONAL APPLICATION NO.  
PCT/JP00/05980INTERNATIONAL FILING DATE  
04 September 2000PRIORITY DATE CLAIMED  
02 September 1999TITLE OF INVENTION  
CASKAPPLICANT(S) FOR DO/EO/US  
Katunari OHSONO, et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☐ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
  - a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☒ has been transmitted by the International Bureau.
  - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210).
8. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
  - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
  - b. ☐ have been transmitted by the International Bureau.
  - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
  - d. ☒ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

## Items 13 to 20 below concern document(s) or information included:

13. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☐ Certificate of Mailing by Express Mail
20. ☒ Other items or information:

## Request for Consideration of Documents Cited in International Search Report

Notice of Priority

PCT/IB/304

PCT/IB/308

Drawings (20 Sheets)

Letter Requesting Entry of Substitute Drawings

Substitute Figure (7)

21. The following fees are submitted:

**BASIC NATIONAL FEE ( 37 CFR 1.492 (a) (1) - (5) ) :**

- |                                     |   |            |
|-------------------------------------|---|------------|
| <input type="checkbox"/>            | Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO . . . . . | \$1,000.00 |
| <input checked="" type="checkbox"/> | International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO . . . . .   | \$860.00   |
| <input type="checkbox"/>            | International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO . . . . .  | \$710.00   |
| <input type="checkbox"/>            | International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) . . . . .   | \$690.00   |
| <input type="checkbox"/>            | International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) . . . . .   | \$100.00   |

**ENTER APPROPRIATE BASIC FEE AMOUNT =**

**\$860.00**

Surcharge of **\$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).

**\$0.00**

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	17 - 20 =	0	x \$18.00	\$0.00
Independent claims	5 - 3 =	2	x \$80.00	\$160.00
Multiple Dependent Claims (check if applicable).			<input type="checkbox"/>	\$0.00

### TOTAL OF ABOVE CALCULATIONS

**\$1,020.00**

Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) (check if applicable).

**\$0.00**

**SUBTOTAL =**

**\$1,020.00**

Processing fee of **\$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)).

**\$0.00**

TOTAL NATIONAL FEE

**\$1,020.00**

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable)**.

**\$0.00**

**TOTAL FEES ENCLOSED**

**\$1,020.00**

**Amount to be:  
refunded**

\$

**charged**

\$

- ☒ A check in the amount of **\$1,020.00** to cover the above fees is enclosed.
- ☐ Please charge my Deposit Account No. \_\_\_\_\_ in the amount of \_\_\_\_\_ to cover the above fees.  
A duplicate copy of this sheet is enclosed.
- ☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **15-0030** A duplicate copy of this sheet is enclosed.

**NOTE:** Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:



22850

Surinder Sachar  
Registration No. 34,423

SIGNATURE

Marvin J. Spivak

NAME \_\_\_\_\_

**24,913**

REGISTRATION NUMBER

DATE \_\_\_\_\_

09/830851

JC08 Rec'd PCT/PTE 02 MAY 2001

DOCKET NO. 206338US

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF: : ATTN: NEW APPLICATION  
DIVISION

KATUNARI OHSONO ET AL

SERIAL NO. NEW U.S. PCT APPLN  
(Based on PCT/JP00/05980

FILED: HEREWITH

FOR: CASK

LETTER REQUESTING ENTRY OF SUBSTITUTE DRAWINGS

ASSISTANT COMMISSIONER FOR PATENTS  
WASHINGTON, D.C. 20231

SIR:

Please review the attached substitute Figure 7, for entry as a replacement for the original Figure 7, in the above-identified application.

Respectfully submitted,

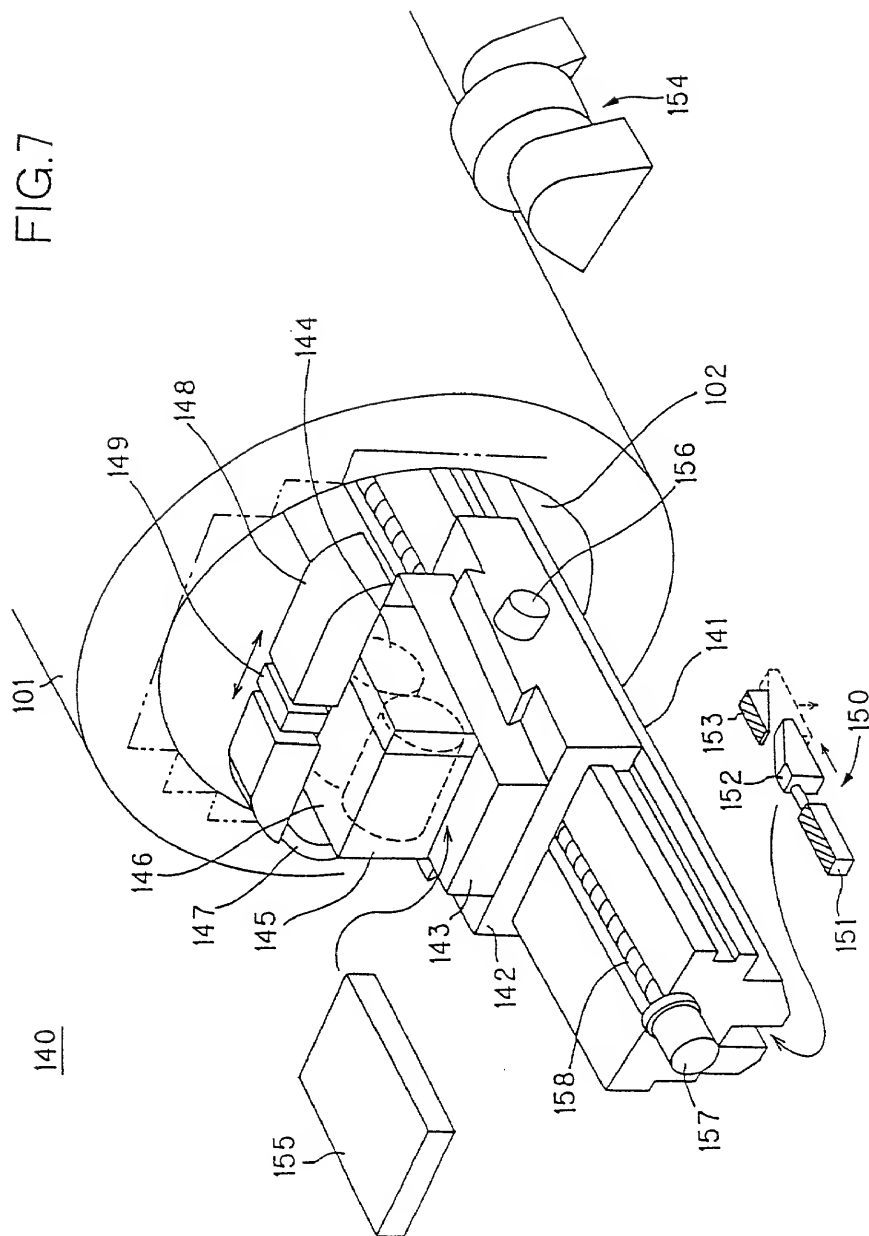
OBLON, SPIVAK, McCLELLAND,  
MAIER & NEUSTADT, P.C.



Gregory J. Maier  
Registration No: 25,599  
Attorney of Record  
Surinder Sachar  
Registration No: 34,423

GJM/SNS/kmh  
P: (703) 413-3000  
F: (703) 413-2220

FIG. 7



09/830851

J008 Rec'd PCT/PTO 02 MAY 2001

206338US

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF: :  
KATUNARI OHSONO ET AL : ATTN: NEW APPLICATION DIVISION  
SERIAL NO: NEW U.S. PCT APPLN. :  
(Based on PCT/JP00/05980)  
FILED: HEREWITH :  
FOR: CASK :

PRELIMINARY AMENDMENT

ASSISTANT COMMISSIONER FOR PATENTS  
WASHINGTON, D.C. 20231

SIR:

Prior to examination on the merits, please amend the above-identified application as follows:

IN THE SPECIFICATION

Please amend the specification as shown in the marked-up copy to read as follows:

Page 7, replace the paragraph beginning at line 19 through page 8, line 3, with the following paragraph:

According to the cask of next invention, the shape of either one of the inner surface of a cavity of a shell main body that has a neutron shielding unit at its outer periphery and shields the  $\gamma$ -rays or the outer surface of a basket that has latticed cells structured by a plurality of angular pipes having neutron absorbing property, is matched with the shape of the other, whereby each used nuclear fuel aggregate is accommodated in each cell of the

basket inserted into the cavity.

Page 11, replace the paragraph at lines 13-20 with the following paragraph:

According to the cask of next invention, spacers are provided between a cavity of a shell main body that has a neutron shielding unit at its outer periphery and shields the  $\gamma$ -rays and a basket that has latticed cells structured by a plurality of angular pipes halving neutron absorbing property, whereby each used nuclear fuel aggregate is accommodated in each cell of the basket inserted into the cavity.

Page 30, replace the paragraph beginning at line 8 through page 31, line 6, with the following paragraph:

As explained above, according to the cask 100 relating to the first embodiment of the present invention, the inside of the cavity 102 of the shell main body 101 is mechanically processed, and the angular pipes 132 that structure the outer periphery of the basket 130 are inserted into the cavity in a closely adhered state. Therefore, it is possible to improve the thermal conductivity of the heat from the angular pipes 132. Further, as the space area inside the cavity 102 can be eliminated, it is possible to make the shell main body 101 in compact and with reduced weight. Even in this case, the number of the angular pipes 132 that can be accommodated is not reduced. On the contrary, when the external diameter of the shell main body 101 is made the same as that of the cask shown in Fig. 19, it becomes possible to secure the number of cells by that amount, and it is possible to increase the number of used nuclear fuel aggregates that can be accommodated. Specifically, the cask 100 can accommodate 69 used nuclear fuel aggregates, and it is also possible to restrict the external diameter of the cask main body 116 to 2,560 mm and its weight to 120 tons. When the above structure is employed, it has actually become possible to accommodate 69 used nuclear fuel aggregates after satisfying the required weight limit and the size limit of the cask.

Page 32, replace the paragraph beginning at line 25 through page 33, line 9, with the following paragraph:

Fig. 12 is a perspective view showing a cask relating to a second embodiment of the present invention. This cask 200 has a structure that spacers 201 for thermal conduction are further provided on the cask 500 shown in Fig. 19. These spacers 201 fill space areas S, and efficiently conduct heat from angular pipes 510 to a shell main body 501. The material for the spacers 201 is carbon steel that is the same as the material for the shell main body 501. The spacers 201 are manufactured by casting or forging or by a mechanical processing according to the shapes of the space areas S.

#### IN THE CLAIMS

Please cancel Claims 1-13 without prejudice.

Please add new Claims 14-30 as follows:

14. (New) A cask having a structure that a shape of an inside of a cavity of a shell main body that has a neutron shielding unit at its outer periphery and shields  $\gamma$ -rays is matched with an external shape of a basket having an angular cross section that is structured by a plurality of angular pipes having neutron absorbing property in a status that these pipes are inserted into the cavity, whereby each used nuclear fuel aggregate is accommodated in each cell of the basket inserted into the cavity.

15. (New) The cask according to claim 14, wherein a part of the inside of the cavity is matched with the external shape at the basket.

16. (New) The cask according to claim 14, wherein dummy pipes are further provided, and a shape of a portion within the cavity that has room in a thickness of the shell main body is matched with the shape of the dummy pipes, whereby the dummy pipes are

inserted into the cavity together with the basket in a state that the dummy pipes are in contact with the angular pipes.

17. (New) The cask according to claim 14, wherein auxiliary shielding units for shielding the  $\gamma$ -rays are further provided at portions of an outermost side of the shell main body that has a small thickness of the shell main body.

18. (New) The cask according to claim 14, wherein a plurality of angular pipes that constitute the basket are integrated together before they are inserted into the cavity.

19. (New) A cask having a structure that a shape of either one of an inner surface of a cavity of a shell main body that has a neutron shielding unit at its outer periphery and shields  $\gamma$ -rays and an outer surface of a basket that has latticed cells structured by a plurality of angular pipes having neutron absorbing property, is matched with the shape of the other, whereby each used nuclear fuel aggregate is accommodated in each cell of the basket inserted into the cavity.

20. (New) The cask according to claim 19, wherein dummy pipes are further provided, and a shape of a portion within the cavity that has room in a thickness of the shell main body is matched with the shape of the dummy pipes, whereby the dummy pipes are inserted into the cavity together with the basket in a state that the dummy pipes are in contact with the angular pipes.

21. (New) The cask according to claim 19, wherein auxiliary shielding units for shielding the  $\gamma$ -rays are further provided at portions of an outermost side of the shell main body that has a small thickness of the shell main body.

22. (New) The cask according to claim 19, wherein a plurality of angular pipes that constitute the basket are integrated together before they are inserted into the cavity.

23. (New) A cask having a structure that spacers are provided between a cavity of a



shell main body that has a neutron shielding unit at its outer periphery and shields  $\gamma$ -rays and a basket than has latticed cells structured by a plurality of angular pipes having neutron absorbing property, whereby each used nuclear fuel aggregate is accommodated in each cell of the basket inserted into the cavity.

24. (New) The cask according to claim 23, wherein a plurality of angular pipes that constitute the basket are integrated together before their are inserted into the cavity.

25. (New) A cask comprising:

a basket having a plurality of latticed cells formed for accommodating used nuclear fuel aggregates, by bundling a plurality of angular pipes having neutron absorbing material added to a structural material;

a shell main body having a cylindrical cavity that has been forged from a  $\gamma$ -rays shielding material, and that is plane processed by matching a shape of an inside of the cavity with an external shape of the basket constructed of the angular pipes; and

a neutron shielding unit having a plurality of internal fins extended between the shell main body and an external cylinder, and for shielding neutrons filled in a space formed by the shell main body, the external cylinder, and the internal fins, wherein

the angular pipe are sequentially inserted into the cavity to structure the basket while bringing the outer surface of the basket into contact with the inner surface of the cavity.

26. (New) A cask having a structure that a shape of an inside of a cavity of a shell main body that has a neutron shielding unit at its outer periphery and shields  $\gamma$ -rays is matched with an external shape of a basket that has a latticed angular cross-sectional shape by alternately combining in an orthogonal direction a plurality of plates having neutron absorbing property, whereby each used nuclear fuel aggregate is accommodated in each cell of the basket inserted into the cavity.

27. (New) The cask according to claim 26, wherein a part of the inside of the cavity is matched with the external shape of the basket.

28. (New) The cask according to claim 26, wherein dummy pipes are further provided, and a shape of a portion within the cavity that has room in a thickness of the shell main body is matched with the shape of the dummy pipes, whereby the dummy pipes are inserted into the cavity together with the basket in a state that the dummy pipes are in contact with the plates.

29. (New) The cask according to claim 26, wherein when the basket is constructed by combining the plates, a thermal conductive plate having a contact with the cavity wall is provided at an end of each plate positioned at the outer periphery of the basket.

30. (New) The cask according to claim 26, wherein when the basket is constructed by combining the plates, a thermal conductive plate is provided between an end of each plate positioned at the outer periphery of the basket and an end of the other plate.

#### IN THE DRAWING

Approval of the attached substitute Figure 7 is respectfully requested.

#### REMARKS

Favorable consideration of this application, as presently amended, is respectfully requested.

The present Preliminary Amendment is submitted to place the above-identified application in more proper format under United States practice.

By the present Preliminary Amendment the specification has been amended to correct for minor informalities.

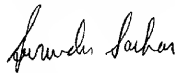
Original Claims 1-13 have been canceled and new Claims 14-30 are presented for examination. New Claims 14-30 are believed to be self-evident from the original disclosure, including original Claims 1-13, and thus are not deemed to raise any issues of new matter.

A new substitute Figure 7 is also submitted herewith which correctly labels element 144.

The present application is believed to be in condition for a full and thorough examination on the merits. An early and favorable consideration of the present application is hereby respectfully requested.

Respectfully submitted,

OBLON, SPIVAK, McCLELLAND,  
MAIER & NEUSTADT, P.C.



Gregory J. Maier  
Registration No. 25,599  
Attorney of Record  
Surinder Sachar  
Registration No. 34,423



**22850**

(703) 413-3000  
Fax #: (703) 413-2220  
GJM:SNS/cct

I:\atty\SNS\206338US-pr.wpd

**Marked-Up Copy**

Serial No: \_\_\_\_\_

Amendment Filed on: \_\_\_\_\_

IN THE SPECIFICATION

Please amend the specification as follows:

Page 7, replace the paragraph beginning at line 19 through page 8, line 3, with the following paragraph:

--According to the cask of next invention, [in the cask of the above-mentioned invention,] the shape of either one of the inner surface of a cavity of a shell main body that has a neutron shielding unit at its outer periphery and shields the  $\gamma$ -rays or the outer surface of a basket that has latticed cells structured by a plurality of angular pipes having neutron absorbing property, is matched with the shape of the other, whereby each used nuclear fuel aggregate is accommodated in each cell of the basket inserted into the cavity.--

Page 11, replace the paragraph at lines 13-20 with the following paragraph:

--According to the cask of next invention, [in the cask of the above-mentioned invention,] spacers are provided between a cavity of a shell main body that has a neutron shielding unit at its outer periphery and shields the  $\gamma$ -rays and a basket that has latticed cells structured by a plurality of angular pipes halving neutron absorbing property, whereby each used nuclear fuel aggregate is accommodated in each cell of the basket inserted into the cavity.--

Page 30, replace the paragraph beginning at line 8 through page 31, line 6, with the following paragraph:

--As explained above, according to the cask 100 relating to the first embodiment of the present invention, the inside of the cavity 102 of the shell main body 101 is mechanically processed, and the angular pipes 132 that structure the outer periphery of the basket 130 are inserted into the cavity in a closely adhered state. Therefore, it is possible to improve the thermal conductivity of the heat from the angular pipes 132. Further, as the space area inside the cavity 102 can be eliminated, it is possible to make the shell main body 101 in compact and with reduced weight. Even in this case, the number of the angular pipes 132 that can be accommodated is not reduced. On the contrary, when the external diameter of the shell main body 101 is made the same as that of the cask shown in Fig. [16] 19, it becomes possible to secure the number of cells by that amount, and it is possible to increase the number of used nuclear fuel aggregates that can be accommodated. Specifically, the cask 100 can accommodate 69 used nuclear fuel aggregates, and it is also possible to restrict the external diameter of the cask main body 116 to 2,560 mm and its weight to 120 tons. When the above structure is employed, it has actually become possible to accommodate 69 used nuclear fuel aggregates after satisfying the required weight limit and the size limit of the cask.--

Page 32, replace the paragraph beginning at line 25 through page 33, line 9, with the following paragraph:

--Fig. 12 is a perspective view showing a cask relating to a second embodiment of the present invention. This cask 200 has a structure that spacers 201 for thermal conduction are further provided on the cask 500 shown in Fig. [16] 19. These spacers 201 fill space areas S, and efficiently conduct heat from angular pipes 510 to a shell main body 501. The material for the spacers 201 is carbon steel that is the same as the material for the shell main body 501. The spacers 201 are manufactured by casting or forging or by a mechanical processing according to the shapes of the space areas S.--

IN THE CLAIMS

Claims 1-13 (Canceled).

Claims 14-30 (New).

## SPECIFICATION

## TITLE OF THE INVENTION

Cask

5

## TECHNICAL FIELD

The present invention relates to a cask for accommodating and storing used nuclear fuel aggregates after the nuclear fuel has been combusted. This invention relates to a cask having improved thermal conductivity and higher accommodation capacity, being compact in size and light in weight.

## BACKGROUND ART

15 A nuclear fuel aggregate that is at a final stage of a nuclear fuel cycle and that has finished combustion and cannot be used anymore is called a used nuclear fuel aggregate. The used nuclear fuel aggregate includes a high radioactive material such as FP and is therefore necessary to be thermally cooled. For this purpose, the used nuclear fuel aggregate is cooled in a cooling pit at a nuclear power plant during a predetermined period of time (3 to 6 months). Thereafter, the cooled used nuclear fuel aggregate is accommodated in a cask that is a shielding vessel, and the used nuclear fuel  
20 aggregate accommodated in the cask is carried to a  
25

reprocessing facility by a track and the like, and is stored there. For accommodating the used nuclear fuel aggregate into the cask, a holding element having a latticed cross section called a basket is used. Each used nuclear fuel  
5 aggregate is inserted into each of cells that are a plurality of accommodation spaces formed in the basket. With this arrangement, a proper holding force is secured for holding the used nuclear fuel aggregate against vibrations during the transportation.

10 As prior examples of such a cask, various kinds of casks have been disclosed in, for example, the "Nuclear Eye (in Japanese), Nikkan Kogyo Shuppan Production, issued on April 1, 1998, and Japanese Patent Application Laid-open Publication No. 62-242725. A cask based on which the present  
15 invention has been made will be explained below. It should be noted that this cask is shown for the convenience of the explanation, and does not correspond to a publicly known or publicly used one.

Fig. 19 is a perspective view showing one example of  
20 a cask. Fig. 20 is a cross-sectional view of the cask cut along an axial direction of the cask shown in Fig. 19. A cask 500 is constructed of a cylindrical shell main body 501, resin 502 as a neutron shielding unit provided on an outer periphery of the shell main body 501, an external  
25 cylinder 503, a bottom section 504, and a lid section 505.



The shell main body 501 and the bottom section 504 have been forged from carbon steel as  $\gamma$ -rays shielding units. The lid section 505 consists of a primary lid 506 and a secondary lid 507 made of stainless steel or the like. The shell main body 501 and the bottom section 504 are connected together by butt-welding. The primary lid 506 and the secondary lid 507 are fixed to the shell main body 501 by bolts made of stainless steel. A metal-made O-ring exists between the lid section 505 and the shell main body 501, thereby holding an airtight condition inside the used nuclear fuel aggregate.

Between the shell main body 501 and the external cylinder 503, a plurality of internal fins 508 are provided for carrying out a thermal conduction. Copper is used for the internal fin 508 to increase the thermal conductivity. The resin 502 is injected in a fluid state into spaces formed by the internal fins 508, and is cooled and solidified afterward. The basket 509 has a structure of having 69 angular pipes 510 assembled in a bundle as shown in Fig. 19, and is inserted into a cavity 511 of the shell main body 501 in a constrained state.

The angular pipes 510 are made of aluminum alloy having neutron absorbing material (e.g. boron: B) mixed into it in order to avoid the used nuclear fuel aggregate from reaching a criticality. On both sides of a cask main body 512, trunnions 513 (one is not shown in the drawing) are

provided for suspending the cask 500. Further, on both ends of the cask main body 512, there are installed buffers 514 (one is not shown in the drawing) that have wood built inside thereof as a buffering material.

5        When actually manufacturing the cask 500, it is usually necessary to investigate on design conditions such as the number of used nuclear fuel aggregates, and their sizes and weights, etc. Specifically, it is preferable that the cask can accommodate a large number of used nuclear fuel  
10 aggregates, has a small external diameter, and has lightweight. However, according to the structure of the above cask 500, as the angular pipes 510 are in line contact with the inner surface of the cavity 511 at the outermost periphery, a space area S is formed between the basket 509  
15 and the cavity 511. Therefore, the thermal conduction from cells 515 to the shell main body 501 cannot be carried out efficiently. Further, as the diameter of the shell main body 501 becomes large because of the existence of the space area S, the cask 500 has a heavy weight.

20        On the other hand, the volume of radiation that is leaked to the outside of the cask is prescribed by the total volume of neutron and  $\gamma$ -rays. Therefore, in order to reduce the weight of the cask 500, the thickness of the shell main body 501 may be made smaller. However, because of the  $\gamma$ -rays  
25 shielding unit, the cask is required to have a thickness

that is sufficient enough to secure a  $\gamma$ -rays shielding function at the shell main body 501 side. While the cask 500 can accommodate the unconventional number of 69 fuel assemblies, this number of accommodating the used nuclear fuel aggregates is reduced when the diameter of the shell main body 501 is made smaller in the structure to accommodate the used nuclear fuel aggregates within a predetermined weight.

It is an object of the present invention to provide a cask that has any one of the following. That is, improved thermal conductivity, higher accommodation capacity, compact size, and light weight.

#### DISCLOSURE OF THE INVENTION

The cask according to this invention has the shape of the inside of a cavity of a shell main body that has a neutron shielding unit at its outer periphery and shields the  $\gamma$ -rays is matched with the external shape of a basket that has latticed cells structured by a plurality of angular pipes having neutron absorbing property, whereby each used nuclear fuel aggregate is accommodated in each cell of the basket inserted into the cavity.

Each used nuclear fuel aggregate generates a radiation and has decay heat. The used nuclear fuel aggregates are accommodated into the cells of the basket structured by

angular pipes. The shape of the inside of the cavity of the shell main body is matched with the external shape of the basket. Therefore, when the basket is inserted into the cavity, the angular pipes at the outside are brought  
5 into a plane contact with the inner surface of the cavity. As the shape of the inside of the cavity is matched with the external shape of the basket, no space area is generated between the angular pipes and the cavity. Therefore, the decay heat is efficiently conducted from the basket to the  
10 shell main body.

Further, as there is no space area inside the cavity, it is possible to make smaller the external diameter of the shell main body. On the other hand, when the external diameter of the shell main body is made the same as that  
15 of the shell main body as shown in Fig. 19, it becomes possible to insert more angular pipes. As the angular pipes have the neutron absorbing property, the angular pipes do not reach the criticality when the angular pipes have accommodated the used nuclear fuel aggregates. The  $\gamma$ -rays  
20 that has been generated from the used nuclear fuel aggregates is shielded by the shell main body, and at the same time, neutron is shielded by the neutron shielding unit.

According to the cask of next invention, in the cask of the above-mentioned invention, a part of the inside of  
25 the cavity is matched with the external shape of the basket.

It is not necessary to match the shape of the whole inside of the cavity with the external shape of the basket. When the shape of only a part of the inside of the cavity is matched with the external shape of the basket, it is also possible to obtain the same operation and effects as those of the cask of the above-mentioned invention.

In other words, when the shape of a part of the inside of the cavity is matched with the external shape of the basket, it is possible to secure a contact area between the inner surface of the cavity and the angular pipes, and at the same time, it is possible to make smaller the space area within the cavity. Therefore, it is possible to efficiently carry out a thermal conduction. Further, it is possible to make smaller the external diameter of the shell main body by the portion of the space area that has been reduced. On the other hand, when the external diameter of the shell main body is left as it is, it becomes possible to increase the number of accommodating the used nuclear fuel aggregates.

According to the cask of next invention, in the cask of the above-mentioned invention, the shape of either one of the inner surface of a cavity of a shell main body that has a neutron shielding unit at its outer periphery and shields the  $\gamma$ -rays or the outer surface of a basket that has latticed cells structured by a plurality of angular pipes having neutron absorbing property, is matched with the shape

of the other, whereby each used nuclear fuel aggregate is accommodated in each cell of the basket inserted into the cavity.

The used nuclear fuel aggregates accommodated within  
5 the cells of the basket have a radiation and decay heat, and this decay heat reaches the outer surface of the basket through the cells. As the outer surface of the basket and the inner surface of the cavity are in contact with each other by matching the shape of one of these surfaces with  
10 the shape of the other, the decay heat is efficiently conducted from the basket to the shell main body, and is radiated to the outside. When the shape of the inner surface of the cavity is matched with the shape of the outer surface of the basket, there is no space area inside the cavity.  
15 Therefore, it is possible to make smaller the external diameter of the shell main body. On the other hand, when the shape of the outer surface of the basket is matched with the shape of the inner surface of the cavity, it becomes possible to insert more angular pipes.

20 In this case, in matching the shape of one of the outer surface of the basket and the inner surface of the cavity with the shape of the other, for example, the shape of the inner surface of the cavity may be matched with the shape of the outer surface of the basket, thereby plane processing  
25 the inner surface of the cavity. Alternatively, the shape

of the outer surface of the basket may be matched with the shape of the inner surface of the cavity, thereby shaping the cells of the outer periphery. The above contact state does not necessarily mean that the inner surface of the cavity and the outer surface of the basket are always in complete contact with each other, but that this contact state also includes a state that there is a slight gap or the contact is temporarily cancelled.

According to the cask of next invention, in the cask of the above-mentioned invention, dummy pipes are further provided, and the shape of a portion within the cavity that has room in the thickness of the shell main body is matched with the shape of the dummy pipes, whereby the dummy pipes are inserted into the cavity together with the basket in a state that the dummy pipes are in contact with the angular pipes.

When the shape of the inside of the cask is matched with the external shape of the basket, the thickness of the shell main body becomes inhomogeneous. However, when the shell main body has secured a predetermined thickness for shielding the  $\gamma$ -rays, the other additional thickness portion becomes a cause of increasing the weight of the cask. Therefore, in the cask of this aspect, the shape of a portion within the cavity that has room in the thickness is matched with the shape of the dummy pipes, and the dummy pipes are

inserted into this portion, thereby reducing the weight of the cask.

Further, as the dummy pipes are inserted into the cavity in a state that they are brought into contact with the angular pipes, the dummy pipes work as a medium for conducting heat from the angular pipes to the shell main body, and also have a function of pressing the angular pipes together to keep them in contact with each other. Based on this arrangement, it becomes possible to improve the thermal conductivity between the angular pipes. Further, the shape and the number of dummy pipes are suitably selected as necessary. The state of keeping the dummy pipes in contact with the angular pipes means that they are not necessarily always in complete contact with each other, as is the case with the above aspect.

According to the cask of next invention, in the cask of the above-mentioned invention, auxiliary shielding units for shielding the  $\gamma$ -rays are further provided at portions of the outermost side of the shell main body that has a small thickness of the shell main body.

When the shape of the inside of the cavity is matched with the external shape of the basket, for example, the thickness of the shell main body becomes small at a corner portion of the basket. Therefore, the  $\gamma$ -rays shielding capacity is lowered at this portion. Thus, the auxiliary shielding unit is provided at this portion, thereby



increasing the  $\gamma$ -rays shielding capacity. In providing the auxiliary shielding unit at the outside of the shell main body, the auxiliary shielding unit may be provided at a position where the auxiliary shielding unit is in contact  
5 with the outer surface of the shell main body. Alternatively, the auxiliary shielding unit may be embedded into the neutron shielding unit with a slight distance from the outer surface of the shell main body. The material of the auxiliary shielding unit may be the same as that of the shell main  
10 body, or may be different from the material of the shell main body so long as the material has a the  $\gamma$ -rays shielding capacity.

According to the cask of next invention, in the cask of the above-mentioned invention, spacers are provided  
15 between a cavity of a shell main body that has a neutron shielding unit at its outer periphery and shields the  $\gamma$ -rays and a basket that has latticed cells structured by a plurality of angular pipes having neutron absorbing property, whereby each used nuclear fuel aggregate is accommodated in each  
20 cell of the basket inserted into the cavity.

When the basket is inserted into the shell main body having the cavity of a cylindrical shape (see Fig. 19), the basket and the cavity are brought into a line contact with each other. Further, a space area is generated inside the  
25 cavity. Therefore, the decay heat of the used nuclear fuel

aggregates is not easily conducted from the cells to the shell main body. Thus, in this aspect, spacers are inserted into between the cavity and the basket, thereby eliminating the space area and increasing a substantive contact area.

5 Heat is conducted through these spacers.

For these spacers, it is possible to use spacers of the same material as that of the shell main body and having a semicylindrical cross section, or spacers of the same material as that of the cells and having hollow-shaped cross  
10 section formed by extrusion or pressing. Further, spacers may be provided in all spaces between the cavity and the basket, or spacers may be provided at only necessary portions. Based on the above structure, the thermal conductivity from the cells to the shell main body is improved.

15 According to the cask of next invention, in the cask of the above-mentioned invention, a plurality of angular pipes that constitute the basket are integrated together before they are inserted into the cavity. When each one angular pipe is inserted into the cavity, the cask assembly  
20 work becomes troublesome, and a contact interface between the angular pipes interferes with the improvement in thermal conductivity. Thus, a plurality of angular pipes that constitute the basket are integrated together. With this arrangement, it becomes possible to collectively insert the  
25 angular pipes into the cavity, which simplifies the

assembling work. As no contact interface exists, the thermal conductivity is improved further.

The cask according to the next invention comprises a basket having a plurality of latticed cells formed for  
5 accommodating used nuclear fuel aggregates, by bundling a plurality of angular pipes having a neutron absorbing material added to a structural material; a shell main body having a cylindrical cavity that has been forged from  $\gamma$ -rays shielding material, and that is plane processed by matching  
10 the shape of the inside of this cavity with the external shape of the basket constructed of the angular pipes; and a neutron shielding unit having a plurality of internal fins extended between the shell main body and an external cylinder, and for shielding neutrons filled in a space formed by the  
15 shell main body, the external cylinder and the internal fins, whereby the angular pipe are sequentially inserted into the cavity to structure the basket while bringing the outer surface of the basket into contact with the inner surface of the cavity.

20 A radiation and decay heat are generated from the used nuclear fuel aggregates that are accommodated in cells. This decay heat reaches the outer surface of the basket through cells adjacent to the corresponding cells. The inside of the cask is plane processed to match the external  
25 shape of the basket, and the outer surface of the basket

is in contact with the inner surface of the cavity. Therefore, the decay heat is efficiently conducted to the shell main body. The decay heat that has been conducted to the shell main body is radiated from the external cylinder mainly through the internal fins. On the other hand, the neutron that has been generated from the used nuclear fuel aggregates is absorbed by the neutron absorbing material, such as boron, for example, that has been added to the pipes. Thus, the neutron is prevented from reaching the criticality. The  $\gamma$ -rays is shielded by the shell main body, and the neutron is shielded by the neutron shielding unit.

Further, by bringing the outer surface of the basket into contact with the inner surface of the cavity, it is possible to avoid the space area as shown in Fig. 19. Therefore, it is possible to make smaller the external diameter of the shell main body. On the other hand, when the external shape of the shell main body is made the same as that shown in Fig. 19, it becomes possible to insert more angular pipes into the cavity.

The cask according to the next invention has the shape of the inside of a cavity of a shell main body that has a neutron shielding unit at its outer periphery and shields the  $\gamma$ -rays is matched with the external shape of a basket that has a latticed angular cross-sectional shape by alternately combining in an orthogonal direction a plurality

of plates having neutron absorbing property, whereby each used nuclear fuel aggregate is accommodated in each cell of the basket inserted into the cavity.

Further, in a similar manner to that explained above,  
5 it is possible to avoid the space area and, therefore, it is possible to make smaller the external diameter of the shell main body. On the other hand, when the external diameter of the shell main body is made the same as that shown in Fig. 19, it becomes possible to insert more angular  
10 pipes into the cavity. As the angular pipes have the neutron absorbing property, the angular pipes do not reach the criticality when the angular pipes have accommodated the used nuclear fuel aggregates.

According to the cask of next invention, in the cask  
15 of the above-mentioned invention, a part of the inside of the cavity is matched with the external shape of the basket. It is not necessary to match the shape of the whole inside of the cavity with the external shape of the basket. When the shape of only a part of the inside of the cavity is matched  
20 with the external shape of the basket, it is also possible to obtain the same operation and effects as those of the cask of the ninth aspect.

According to the cask of next invention, in the cask of the above-mentioned invention, dummy pipes are further  
25 provided, and the shape of a portion within the cavity that

has room in the thickness of the shell main body is matched with the shape of the dummy pipes, whereby the dummy pipes are inserted into the cavity together with the basket in a state that the dummy pipes are in contact with the plates.

5 Further, as the dummy pipes are inserted into the cavity in a state that they are brought into contact with the plates, the dummy pipes work as a medium for conducting heat from the basket to the shell main body. Based on this arrangement, it becomes possible to improve the thermal conductivity from  
10 the basket to the shell main body. The state of keeping the dummy pipes in contact with the plates means that they are not necessarily always in complete contact with each other, as is the case with the above aspect.

According to the cask of next invention, in the cask  
15 of the above-mentioned invention, when the basket is constructed by combining the plates, a thermal conductive plate having a contact with the cavity wall is provided at the end of each plate positioned at the outer periphery of the basket.

20 According to the cask of next invention, in the cask of the above-mentioned invention, when the basket is constructed by combining the plates, a thermal conductive plate is provided between the end of each plate positioned at the outer periphery of the basket and the end of the other  
25 plate.

Based on the provision of a thermal conductive plate between the ends of the plates, the thermal conductive plates are brought into a plane contact with the internal surface of the cavity of the shell main body. Therefore, it becomes possible to improve the thermal conductivity from the plates to the shell main body.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view showing a cask relating to a first embodiment of the present invention; Fig. 2 is a cross-sectional view of the cask cut along a radial direction of the cask shown in Fig. 1; Fig. 3 is a cross-sectional view of the cask cut along an axial direction of the cask shown in Fig. 1; Fig. 4 is a flowchart showing a method of manufacturing an angular pipe; Fig. 5 is an explanatory view showing a state of a cross-section of the angular pipe; Fig. 6 is a perspective view showing a method of inserting the angular pipes; Fig. 7 is a schematic perspective view showing an apparatus for processing a cavity; Fig. 8 shows schematic perspective views for explaining a method of processing the cavity; Fig. 9 shows perspective views of a modified example of a basket; Fig. 10 is a top plan view showing another modified example of the basket; Fig. 11 is a top plan view showing still another modified example of the basket; Fig. 12 is a perspective

view showing a cask relating to a second embodiment of the present invention; Fig. 13 is a cross-sectional view of a cask cut along a radial direction of the cask relating to a third embodiment of the present invention; Fig. 14 is a cross-sectional view of a cask cut along a radial direction of the cask relating to a fourth embodiment of the present invention; Fig. 15 is a cross-sectional view of another cask cut along a radial direction of the cask relating to the fourth embodiment of the present invention; Fig. 16 is a cross-sectional view of a cask cut along a radial direction of the cask relating to a fifth embodiment of the present invention. Fig. 17 is a view for explaining a structure of a basket of the cask shown in Fig. 16. Fig. 18 is a view for explaining a structure of a basket of the cask shown in Fig. 16; Fig. 19 is a perspective view showing one example of a cask; Fig. 20 is a cross-sectional view of the cask cut along an axial direction of the cask shown in Fig. 19.

#### BEST MODE FOR CARRYING OUT THE INVENTION

A cask relating to the present invention will be explained in detail below with reference to the drawings. It should be noted that the present invention is not limited to the following embodiments.

Fig. 1 is a perspective view showing a cask relating to a first embodiment of the present invention. Fig. 2 is



a cross-sectional view of the cask cut along a radial direction of the cask shown in Fig. 1. Fig. 3 is a cross-sectional view of the cask cut along an axial direction of the cask shown in Fig. 1. A cask 100 relating to the first embodiment is provided by mechanically processing the inner surface of a cavity 102 of a shell main body 101 to match the shape of the inner surface of the cavity with the shape of the outer periphery of a basket 130. The mechanical processing of the inner surface of the cavity 102 is carried out by milling the cavity 102 with an exclusive processing apparatus to be described later. A shell main body 101 and a bottom plate 104 have been forged from carbon steel having a  $\gamma$ -rays shielding function. A stainless steel may also be used instead of the carbon steel. The shell main body 101 and the bottom plate 104 are connected together by welding. Further, in order to secure a sealing function of a pressure-resistant vessel, a metal gasket is provided between a primary lid 110 and the shell main body 101.

A resin 106 that is a high polymer material including much hydrogen and having neutron shielding function is filled between the shell main body 101 and an external cylinder 105. Further, a plurality of copper internal fins 107 for carrying out a thermal conduction is welded between the shell main body 101 and the external cylinder 105. The resin 106 is injected in a fluid state into spaces formed by the internal

fins 107, and is cooled and solidified afterward. It is preferable that the internal fins 107 are provided in a high density at a portion where there is much heat quantity, in order to homogenize the heat radiation. A thermal expansion margin 108 of a few mm is provided between the resin 106 and the external cylinder 105. This thermal expansion margin 108 is formed in the following process. First, a vanish type having a heater embedded into a hot melt adhesive or the like is disposed on the inner surface of the external cylinder 105, then the resin 106 is injected into this and solidified, and the heater is heated to melt the adhesive to flow it out thereby forming the margin (not shown).

A lid section 109 is constructed of the primary lid 110 and a secondary lid 111. This primary lid 110 is made of stainless steel or carbon steel having a  $\gamma$ -rays shielding function, and is formed in a disk shape. The secondary lid 111 is also made of stainless steel or carbon steel, and is formed in a disk shape. On the upper surface of the secondary lid 111, a resin 112 is sealed as a neutron shielding unit. A metal gasket is provided between the primary lid 110 and the secondary lid 111, and between the secondary lid 111 and the shell main body 101, respectively, thereby holding the internal sealing. An auxiliary shielding unit 115 having a resin 114 sealed therein is provided around the lid section 109.

On both sides of a cask main body 116, trunnions 117 are provided for suspending the cask 100. While Fig. 1 shows a state that the auxiliary shielding unit 115 has been installed, this auxiliary shielding unit 115 is taken out and buffer units 118 are installed on the cask 100 at the time of carrying the cask 100 (see Fig. 2). The buffer units 118 have a structure that a buffering material such as a read wood material 119 has been built into an external cylinder 120 that is prepared by a stainless steel material.

The basket 130 is constructed of 69 angular pipes 132 that structure cells 131 for accommodating used nuclear fuel aggregates. For the angular pipes 132, there are used an aluminum composite or an aluminum alloy that is prepared by adding a powder of boron or a boron compound having neutron absorbing property to a powder of Al or an Al alloy. Instead of boron, cadmium may also be used for the neutron absorbing material.

Fig. 4 is a flowchart showing a method of manufacturing the angular pipe. First, a powder of Al or an Al alloy is prepared based on a rapid cooling solidification method such as an atomizing method (step S401). Then, a powder of boron or a boron compound is prepared (step S402). Both particles are mixed together for 10 to 15 minutes with a cross rotary mixer or the like (step S403).

For the above aluminum or aluminum alloy, there may

be used any one of pure aluminum metal, Al-Cu aluminum alloy, Al-Mg aluminum alloy, Al-Mg-Si aluminum alloy, Al-Zn-Mg aluminum alloy, and Al-Fe aluminum alloy. For the boron or boron compound, there may be used  $B_4C$ , or  $B_2O_3$ . It is preferable that the volume of boron to be added to aluminum is within the range of not less than 1.5 weight % and not more than 7 weight %. When the volume is less than 1.5 weight %, it is not possible to obtain a sufficient neutron absorbing property, and when the volume is larger than 7 weight %, a stretch at the time of tension is lowered.

Next, the mixed powder is sealed into a rubber case, and is applied with homogeneous pressure by CIP (Cold Isostatic Press) from all directions at a normal temperature, thereby carrying out a powder molding (step S404). The CIP molding is carried out under a condition that the molding pressure is 200 MPa, the diameter of a molded product is 600 mm, and the length of the molded product is 1,500 mm. Based on the application of homogeneous pressure from all directions by the CIP, it becomes possible to obtain a molded product of high density with small variation in the density of the molded product.

Next, the powder molded product is sealed into a can in vacuum, and this is heated to 300 °C (step S405). In this degassing process, the gas component and water component within the can is removed. At the next step, the vacuum

degassed molded product is remolded by HIP (Hot Isostatic Press) (step S406). The HIP molding is carried out under a condition that the molding temperature is within a range from 400 °C to 450 °C, the molding time is 30 seconds, the molding pressure is 6,000 tons, and the diameter of the molded product is 400 mm. Then, in order to remove the can, the outside and the end surfaces are cut (step S407), and the billet is hot extruded by using a porthole extruder (step S408). The extrusion is carried out under a condition that the heating temperature is within a range from 500 °C to 520 °C, and the extrusion speed is 5 m/min. This condition is suitably changed based on the weight of boron included in the billet.

After the extrusion molding, the shape of the billet is corrected by tension (step S409), and a non-steady portion and an evaluation portion are cut out, thereby providing a finished product as an angular pipe (step S410). The completed angular pipe has a square shape with 162 mm for one side of a cross section, and 151 mm for an internal side. A minus tolerance of dimension is 0 because of the required standard. The R of an inside angle is set to 5 mm, and the R of an outside R is set to 0.5 mm to have a sharp edge.

When the R of the edge portion is taken large, a stress applied to the basket 130 is concentrated to a specific portion (near the edge) of the angular pipe 132, which becomes

a cause of damaging the basket. Therefore, by providing the angular pipe 132 with a sharp edge, a stress applied to this angular pipe is transferred straight to the adjacent angular pipe 132, which makes it possible to avoid a concentration of the stress to a specific portion of the angular pipe 132. As another method of manufacturing the angular pipe 132, the present applicant has already filed an application "Basket and Cask" on May 27, 1999. Therefore, the angular pipes may be manufactured by referring to this method.

Fig. 6 is a perspective view showing a method of inserting the angular pipes. The angular pipes 132 manufactured in the above process are sequentially inserted into the cavity 102 along a processing shape within the cavity 102. As each angular pipe 132 has a bending and a twist and also as the minus tolerance of dimension is 0, the angular pipes 132 cannot be easily inserted into the cavity 102 because of the influence of the accumulation of the tolerance and the bending. When an attempt is made to compulsively insert the angular pipes 132 into the cavity 102, an excessive stress is applied to the angular pipes 132. To avoid this problem, the bending and the twist of the whole or a part of the angular pipe 132 manufactured are measured in advance with a laser measuring apparatus. Then, an optimum position of insertion is calculated based on the measured data by

using a computer. With this arrangement, it becomes easy to insert the angular pipes 132 into the cavity 102, and it becomes possible to homogenize the stress applied to the angular pipes 132.

5 Further, as shown in Fig. 6 and Fig. 2, dummy pipes 133 are inserted on both sides of each row of angular pipe that has five or seven cells within the cavity 102. These dummy pipes 133 have objects of reducing the weight of the shell main body 101, homogenizing the thickness of the shell  
10 main body 101, and securely fixing the angular pipes 132. An aluminum alloy including boron is also used for these dummy pipes 133, and these dummy pipes 133 are manufactured in a process similar to that described above. These dummy pipes 133 can also be omitted.

15 The processing of the cavity 102 within the shell main body 101 will be explained next. Fig. 7 is a schematic perspective view showing an apparatus for processing the cavity 102. This processing apparatus 140 is constructed of a fixed table 141 that pierces through the shell main  
20 body 101 and that is fixedly mounted within the cavity 102, a movable table 142 that slides on the fixed table 141 in an axial direction, a saddle 143 that is fixedly positioned on the movable table 142, a spindle unit 146 that is provided on the saddle 143 and is constructed of a spindle 144 and  
25 a driving motor 145, and a face mill 147 provided on the

spindle axis. A reaction force receiver 148 having a contacting section according to the inner shape of the cavity 102 is provided on the spindle unit 146. This reaction force receiver 148 is detachable and slides in an arrow direction  
 5 shown along a dovetail groove (not shown). The reaction force receiver 148 has a clamping unit 149 for clamping the spindle unit 146, and can be fixed at a predetermined position.

A plurality of clamping units 150 is fitted to within  
 10 a groove at a lower part of the fixed table 141. Each clamping unit 150 is constructed of a hydraulic cylinder 151, a wedge-shaped moving block 152 provided on the axis of the hydraulic cylinder 151, and a fixed block 153 that is in contact with the moving block 152 on a sloped surface. A  
 15 shaded side shown in the drawing is fitted to the inner surface of the groove formed on the fixed table 141. When the axis of the hydraulic cylinder 151 is driven, the moving block 152 is brought into contact with the fixed block 153, and the moving block 152 slightly moves downward due to the wedge  
 20 effect (shown by a dotted line in the drawing). As the lower surface of the moving block 152 is pushed against the inner surface of the cavity 102, the fixed table 141 can be fixed within the cavity 102.

The shell main body 101 is mounted on a rotation  
 25 supporting base 154 made of a roller, and is rotatable in



a radial direction. A spacer 155 is inserted into between the spindle unit 146 and the saddle 143, thereby making it possible to adjust the height of the face mill 147 on the fixed table 141. The thickness of the spacer 155 is the same as the size of one side of the angular pipe 132. The saddle 143 moves in a radial direction of the shell main body 101 when a handle 156 provided on the moving table 142 is rotated. The move of the moving table 142 is controlled by a servomotor 157 provided at an end of the fixed table 141 and a ball screw 158. As the processing proceeds, the shape within the cavity 102 changes. Therefore, it is necessary to change the reaction force receiver 148 and the moving block 152 of the clamping mechanism with appropriate ones respectively.

Fig. 8 shows schematic perspective views for explaining a method of processing the cavity. First, the fixed table 141 is fixed at a predetermined position within the cavity 102 by the clamping unit 150 and the reaction force receiver 148. Next, as shown in Fig. 8(a), the spindle unit 146 is moved at a predetermined cutting speed along the fixed table 141, thereby making the face mill 147 cut the inner surface of the cavity 102. When the cutting at this position has been finished, the clamping unit 150 is removed and the fixing table 141 is released. Next, as shown in Fig. 8(b), the shell main body 101 is rotated by 90 degrees

on the rotation supporting table 154, and the fixed table 141 is fixed with the clamping unit 150. Then, the inner surface of the cavity 102 is cut with the face mill 147 in a similar manner. Thereafter, a similar process is repeated  
5 by two times.

Next, the spindle unit 146 is rotated by 180 degrees, and the inner surface of the cavity 102 is cut sequentially as shown in Fig. 8(c). In this case, the shell main body 101 is also rotated by 90 degrees, and the above processing  
10 is repeated. Next, as shown in Fig. 8(d), the spacer 155 is inserted into between the spindle unit 146 and the saddle 143, thereby increasing the height of the spindle unit. At this position, the face mill 147 is fed in an axial direction to cut the inner surface of the cavity 102. This is repeated  
15 while rotating the shell main body 101 by 90 degrees. Thus, an inner shape of the spindle necessary for inserting the angular pipes 132 is substantially completed. The cutting of the portion where the dummy pipes 133 are inserted is also carried out in a similar manner to that shown in Fig.  
20 8(d). However, the thickness of the spacer for adjusting the height of the spindle unit 146 is the same as the size of one side of the dummy pipe 133.

The used nuclear fuel aggregates that are accommodated in the cask 100 include a nuclear fission material and a  
25 fission product, and thus generate a radiation and involve

decay heat. Therefore, it is necessary to securely maintain the heat-removing function, the shielding function and the criticality preventing function of the cask 100 during the storage period (approximately 60 years) respectively.

5 According to the cask 100 relating to the first embodiment of the present invention, the inner surface of the cavity 102 of the shell main body 101 is mechanically processed to accommodate the angular pipes 132 inside the cavity, in a state that the outside of the basket 130 is sealed (not  
10 space area). Further, the internal fins 107 are provided between the shell main body 101 and the external cylinder 105. Therefore, the heat from the fuel bar is conducted to the shell main body 101 through the angular pipes 132 or the filled helium gas, and is radiated from the external  
15 cylinder 105 mainly through the internal fins 107. Based on the above structure, the thermal conductivity of the heat from the angular pipes 132 is improved, and it becomes possible to efficiently remove the decay heat.

Further, the  $\gamma$ -rays generated from the used nuclear  
20 fuel aggregates is shielded by the shell main body 101, the external cylinder 105 and the lid section 109 made of carbon steel or stainless steel respectively. The neutron is shielded by the resin 106 to avoid an influence of exposure to a person engaged in the radiation business. Specifically,  
25 the resin 106 is designed to be able to obtain a shielding

function so that the surface dose equivalent rate becomes not higher than 2 mSv/h and the dose equivalent rate at 1 m height from the surface is not higher than 100  $\mu$ Sv/h. Further, as an aluminum alloy including boron is used for the angular pipes 132 that constitute the cells 131, it is possible to absorb neutron and to prevent the neutron from reaching the criticality.

As explained above, according to the cask 100 relating to the first embodiment of the present invention, the inside of the cavity 102 of the shell main body 101 is mechanically processed, and the angular pipes 132 that structure the outer periphery of the basket 130 are inserted into the cavity in a closely adhered state. Therefore, it is possible to improve the thermal conductivity of the heat from the angular pipes 132. Further, as the space area inside the cavity 102 can be eliminated, it is possible to make the shell main body 101 in compact and with reduced weight. Even in this case, the number of the angular pipes 132 that can be accommodated is not reduced. On the contrary, when the external diameter of the shell main body 101 is made the same as that of the cask shown in Fig. 16, it becomes possible to secure the number of cells by that amount, and it is possible to increase the number of used nuclear fuel aggregates that can be accommodated. Specifically, the cask 100 can accommodate 69 used nuclear fuel aggregates, and it is also

possible to restrict the external diameter of the cask main body 116 to 2,560 mm and its weight to 120 tons. When the above structure is employed, it has actually become possible to accommodate 69 used nuclear fuel aggregates after  
5 satisfying the required weight limit and the size limit of the cask.

A modified example of the basket relating to the first embodiment of the invention will be explained next. Fig. 9 shows perspective views of a modified example of the basket.  
10 While the above-described angular pipe 132 has a simple pipe shape, the basket may also be shaped to have three continuous cells 161 as shown in Fig. 9(a). The basket may also have four continuous cells 162 formed in a square shape as a whole (see Fig. 9(b)), or the basket may have three continuous  
15 cells 163 formed in an L-shape (see Fig. 9(c)). The above-described extrusion molding method may be used for manufacturing these angular pipes. In addition to these modified shapes, there may also be employed other shapes of the basket such as, for example, the basket having four  
20 continuous cells, those cells formed in a T-shape, etc. With this arrangement, it becomes easy to insert the angular pipes.

Fig. 10 is a top plan view showing another modified example of the basket. This basket 170 has a structure that  
25 angular pipes 171 are laid out in a zigzag shape. Therefore,

the cells 172 are formed by not only the inner surfaces of the angular pipes 171 but also by the outer surfaces of the adjacent angular pipes 171. At each corner portion of the angular pipe 171, a fillet 173 is provided. In a state that  
 5 the angular pipes 171 have been inserted into the cavity 102, the fillets 173 of the adjacent angular pipes 171 are butted against each other, and this forms a constrained state as a whole. The thickness of each angular pipe is made larger than that of the angular pipe 132 in order to secure a  
 10 predetermined neutron absorbing property. The dummy pipes 133 may be omitted in this case.

Fig. 11 is a top plan view showing still another modified example of the basket. As shown in this drawing, a basket 180 may be formed in a structure having cells 182  
 15 in a lattice shape by combining corrugated plates 181. A fillet 183 is provided at each corner portion of each corrugated plate 181. The corner portions are butted against the corner portions of the adjacent corrugated plates in a constrained state as a whole. An aluminum alloy  
 20 including boron that has neutron absorbing property is used for the corrugated plate 181. The thickness of each angular pipe is also made larger than that of the angular pipe 132 in order to secure a predetermined neutron absorbing property. The dummy pipes 133 may be omitted in this case as well.

25 Fig. 12 is a perspective view showing a cask relating

to a second embodiment of the present invention. This cask 200 has a structure that spacers 201 for thermal conduction are further provided on the cask 500 shown in Fig. 16. These spacers 201 fill space areas S, and efficiently conduct heat from angular pipes 510 to a shell main body 501. The material for the spacers 201 is carbon steel that is the same as the material for the shell main body 501. The spacers 201 are manufactured by casting or forging or by a mechanical processing according to the shapes of the space areas S.

According to this cask 200, as the space areas S are filled with the spacers 201, it becomes possible to improve the thermal conductivity. Further, as it is possible to improve the rigidity by the spacers 201, it becomes possible to make smaller the external shape of the shell main body 501. As a result, the cask 500 can be provided in compact and in lightweight.

Although the spacers 201 are inserted into the cavity 511 after the angular pipes 510 have been inserted into the cavity 511 in Fig. 12, the angular pipes 510 may be inserted after the spacers 210 have been fastened to the inside of the cavity 511 with bolts. Further, as a predetermined level of rigidity can be secured by the spacers 201, the external shape of the shell main body 501 may be made small by that amount.

Other material that can promote a thermal conduction

can also be used instead of the spacers 201 shown in Fig. 12. For example, internal fins may be provided between the angular pipes 510 and the shell main body 501, and a resin may be further provided between the internal fins (not shown).  
5 Alternatively, dummy pipes formed according to the shapes of the space areas S may be inserted (not shown).

Fig. 13 is a cross-sectional view of a cask cut along a radial direction of the cask relating to a third embodiment of the present invention. According to a shell main body  
10 301 of this cask 300, the inside of a cavity 304 is not plane processed to bring angular pipes 303 at the outer periphery into a complete contact with the cavity 304. Instead, the inside of the cavity 304 has been processed such that a part of the angular pipes 303 is brought into contact with the  
15 inner surface of the cavity 304 by remaining some space areas Sa. In other words, a plurality of grooves 305 are processed at twelve positions of a cylindrical inner surface of the cavity 304 to allow a part of the angular pipes 303 to be engaged with these grooves 305. According to this structure,  
20 it becomes possible to reduce the processing volume of the shell main body 301, which improves productivity. Further, the number of portions at which the angular pipes 303 are directly brought into contact with the shell main body 301 increases, and the space areas Sa within the cavity 304 can  
25 be made smaller. Therefore, it becomes possible to improve



the thermal conductivity more than it is possible to improve by the cask 500 shown in Fig. 16, though the thermal conductivity is lower than that obtained from the cask 100 of the first embodiment. Further, it becomes possible to make the cask 300 in compact and in lightweight. Other constituent elements of this cask 300 are the same as those of the cask 100 of the first embodiment, and therefore, their explanation will be omitted.

Fig. 14 is a cross-sectional view of a cask cut along a radial direction of the cask relating to a fourth embodiment of the present invention. This cask 400 is characterized in that the internal shape of the cavity shown in the first embodiment has been modified to enable 77 angular pipes 401 to be inserted into the cavity. In this structure, the thickness of a shell main body 402 becomes smaller at four corners of the cavity 403. Therefore, auxiliary shielding units 404 for shielding the  $\gamma$ -rays are provided at the four corners to reinforce the shell main body 402. These auxiliary shielding units 404 are made of carbon steel as the shell main body 401 is made of the same material.

Based on the above structure, it is possible to increase the number of cells of a basket 405. Therefore, it becomes possible to increase the number of accommodating used nuclear fuel aggregates. While the present embodiment shows 69 and 77 cells, the cells may be used by other numbers so long

as the angular pipes 401 can be brought into contact with the inner surface of the cavity, subject to a condition that a predetermined weight and a predetermined external diameter can be secured. Other constituent elements of this cask 5 300 are 400 the same as those of the cask 100 of the first embodiment, and therefore, their explanation will be omitted.

Fig. 15 shows other modified example. This cask 450 has a structure that eight grooves 454 are mechanically 10 processed on the inner surface of a cavity 452 of a shell main body 451 to allow a part of angular pipes 453 to be engaged with these grooves, thereby increasing the number of accommodation of used nuclear fuel aggregates to 77. At portions where the thickness of the shell main body 451 15 becomes smaller, auxiliary shielding units 455 made of carbon steel for shielding the  $\gamma$ -rays are provided to reinforce the shell main body 455, in a similar manner as described above. Further, spacers (not shown) may be inserted into space areas Sb between a basket 456 and the shell main body 20 451 to match the shapes of these space areas. Other constituent elements of this cask 450 are the same as those of the cask 200 of the second embodiment, and therefore, their explanation will be omitted.

Fig. 16 is a cross-sectional view of a cask cut along 25 a radial direction of the cask relating to a fifth embodiment

of the present invention. Fig. 17 and Fig. 18 are views for explaining a structure of a basket of the cask shown in Fig. 16. This cask 600 is characterized in that a basket 601 is constructed by alternately combining a plurality of plates 602. In this combined status, the basket 601 is formed in approximately an angular cross section. A plurality of recesses 603 are formed on both sides of each plate 602 in its longitudinal direction. These plates 602 are combined together by mutually engaging the respective recesses 603.

10 Although not shown in the drawing, the end of each plate 602 in its longitudinal direction may be chamfered, or R may be formed on this end. Based on this arrangement, it is possible to smoothly insert used nuclear fuel aggregates into the basket 601 without a scratch in the middle of the basket 601. Thus, the basket 601 having a plurality of cells 131 can be formed based on an alternated combination of the plates 602. As shown in Fig. 18, of the plates 602 used at both ends of the basket 601, plates 602x at the side in one direction have their width in half. Therefore, the  
20 end of the basket 601 is formed in a plane.

For the plates 602, there are used an aluminum composite or an aluminum alloy that is prepared by adding a powder of boron or a boron compound having neutron absorbing property to a powder of Al or Al alloy. These plates 602  
25 are manufactured by extrusion as explained in Fig. 4. The

recesses 603 are formed by cutting or punching after the extrusion. Alternately, each plate 602 may be in a structure that a boron plate has been adhered to an aluminum plate (not shown).

5 Further, a thermal conductive plate 603 is provided between ends 602a of the plates 602 that are positioned at the outer periphery of the basket 601 as shown in Fig. 18. Each thermal conductive plate 603 is fixed by engaging its recesses 603a with projections 602b provided at the end 602a  
10 of each plate 602, and fastening the thermal conductive plate with screws or by spot welding. Alternately, the thermal conductive plate 603 may be directly welded to the end surface of each plate, instead of providing the projections 602b. Based on these thermal conductive plates 603, it is possible  
15 to improve the thermal conductivity of decay heat generated from the used nuclear fuel aggregates from the plates 602 to a shell main body 101.

Further, dummy pipes 133 are inserted into both sides of angular pipe strings having five or seven cells in the  
20 cavity 102. These dummy pipes 133 are provided for the purpose of reducing the weight of the shell main body 101, making uniform the thickness of the shell main body 101, and ensuring the fixing of the basket 601. These dummy pipes 133 are also manufactured by using an aluminum alloy  
25 including boron in a process similar to that explained above.

It is also possible to omit these dummy pipes 133. Other structures are the same as those of the first embodiment, and therefore, their explanation will be omitted. Constituent elements that are the same as those of the first  
5 embodiment are attached with identical reference numbers.

As explained above, according to the cask 600, the internal shape of the cavity is formed to match the angular cross section of the basket 601 that has been constructed by combining the plates 602. Therefore, it is possible to  
10 avoid the space area within the cavity 102. As a result, it is possible to make the shell main body 101 compact and to reduce its weight. On the other hand, when the external diameter of the shell main body 101 is set the same as that of the cask shown in Fig. 19, it is possible to secure cells  
15 by the number corresponding to this diameter. Therefore, it is possible to increase the number of accommodating the used nuclear fuel aggregates. Further, based on the provision of the thermal conductive plates 603, it is possible to effectively release the decay heat.

20 In the first to fifth embodiments, the description has been made based on the assumption that the used nuclear fuel aggregates of the PWR type atomic furnace are accommodated. It is also possible to employ a structure similar to that explained above when the used nuclear fuel  
25 aggregates of the BWR type atomic furnace are accommodated.

In the case of the used nuclear fuel aggregates of the BWR type atomic furnace, it is necessary to increase the size of the latticed cells. In this case, the cells need not be arranged in order, and adjacent cells may be out of order, as they have been generally employed in the past.

As explained above, according to the cask of the present invention, the shape of the inside of a cavity of a shell main body that has a neutron shielding unit at its outer periphery and shields the  $\gamma$ -rays is matched with the external shape of a basket that has latticed cells structured by a plurality of angular pipes having neutron absorbing property. Therefore, the angular pipes at the outermost side are brought into a plane contact with the inner surface of the cavity, and there is generated no space area between the angular pipes and the cavity. As a result, the thermal conductivity can be improved, and it also becomes possible to increase the number of accommodation of used nuclear fuel aggregates. Further, it becomes possible to make the cask in compact or in lightweight.

According to the cask of the next invention, a part of the inside of the cavity is matched with the external shape of the basket. Therefore, the thermal conductivity can be improved, though it is not so high as that obtained from the above-described cask, and it also becomes possible to increase the number of accommodation of used nuclear fuel

aggregates. Further, it becomes possible to make the cask in compact or in lightweight.

According to the cask of the next invention, the shape of either one of the inner surface of a cavity of a shell main body that has a neutron shielding unit at its outer periphery and shields the  $\gamma$ -rays and the outer surface of a basket that has latticed cells structured by a plurality of angular pipes having neutron absorbing property, is matched with the shape of the other. Therefore, the thermal conductivity can be improved, and it also becomes possible to increase the number of accommodation of used nuclear fuel aggregates. Further, it becomes possible to make the cask in compact or in lightweight.

According to the cask of the next invention, dummy pipes are further provided, and the shape of a portion within the cavity that has room in the thickness of the shell main body is matched with the shape of the dummy pipes, whereby the dummy pipes are inserted into the cavity together with the basket in a state that the dummy pipes are in contact with the angular pipes. Therefore, it is possible to further reduce the weight of the cask, and it is possible to improve the thermal conductivity.

According to the cask of the next invention, auxiliary shielding units for shielding the  $\gamma$ -rays are further provided at portions of the outermost side of the shell main body

that has a small thickness of the shell main body. Therefore, it is possible to obtain effects similar to those described above without lowering the  $\gamma$ -rays shielding capacity.

According to the cask of the next invention, spacers  
5 are provided between a basket and a cavity. Therefore, it is possible to improve the thermal conductivity of decay heat generated from the used nuclear fuel aggregates.

According to the cask of the next invention, a plurality of angular pipes that constitute the basket are integrated  
10 together before they are inserted into the cavity. Therefore, it becomes easy to assemble the cask. Further, as there is no contact interface between the angular pipes, it becomes possible to improve the thermal conductivity.

The cask of the next invention comprises a basket having  
15 a plurality of latticed cells formed for accommodating used nuclear fuel aggregates, by bundling a plurality of angular pipes having a neutron absorbing material added to a structural material; a shell main body having a cylindrical cavity that has been forged from a  $\gamma$ -rays shielding material,  
20 and that is plane processed by matching the shape of the inside of this cavity with the external shape of the basket formed by the angular pipes; and a neutron shielding unit having a plurality of internal fins extended between the shell main body and an external cylinder, and for shielding  
25 neutrons filled in a space formed by the shell main body,



the external cylinder and the internal fins, whereby the angular pipe are sequentially inserted into the cavity to structure the basket while bringing the outer surface of the basket into contact with the inner surface of the cavity.

5 Therefore, the thermal conductivity can be improved, and it also becomes possible to increase the number of accommodation of used nuclear fuel aggregates. Further, it becomes possible to make the cask in compact or in lightweight.

10 According to the cask of the next invention, the shape of the inside of a cavity of a shell main body that has a neutron shielding unit at its outer periphery and shields the  $\gamma$ -rays is matched with the external shape of a basket that has a latticed angular cross-sectional shape by  
15 alternately combining in an orthogonal direction a plurality of plates having neutron absorbing property. Further, each used nuclear fuel aggregate is accommodated in each cell of the basket inserted into the cavity. Therefore, it is possible to make smaller the external diameter of the shell  
20 main body. As a result, it is possible to make the cask compact or to reduce its weight.

According to the cask of the next invention, a part of the inside of the cavity is matched with the external shape of the basket. As a result, it is possible to make  
25 the cask compact or to reduce its weight, although not to

such a high level achieved in the above cask according to the ninth aspect.

According to the cask of the next invention, dummy pipes are further provided, and the shape of a portion within the cavity that has room in the thickness of the shell main body is matched with the shape of the dummy pipes. Further, the dummy pipes are inserted into the cavity together with the basket in a state that the dummy pipes are in contact with the plates. As a result, it is possible to further reduce the weight of the cask, and to improve the thermal conductivity.

According to the cask of the next invention, when the basket is constructed by combining the plates, a thermal conductive plate is provided between the end of each plate positioned at the outer periphery of the basket and the end of the other plate. Therefore, it becomes possible to improve the thermal conductivity from the plates to the shell mainbody. As a result, it is possible to increase the number of accommodating the used nuclear fuel aggregates.

#### INDUSTRIAL APPLICABILITY

As explained above, the cask of the present invention is useful for improving the thermal conductivity of used nuclear fuel aggregates that have finished combustion, and for accommodating and storing the used nuclear fuel

aggregates by increasing the accommodation number. Further, the cask of the present invention is compact and light weight.

## CLAIMS

1. A cask having a structure that the shape of the inside of a cavity of a shell main body that has a neutron shielding unit at its outer periphery and shields the  $\gamma$ -rays is matched with the external shape of a basket having an angular cross section that is structured by a plurality of angular pipes having neutron absorbing property in a status that these pipes are inserted into the cavity, whereby each used nuclear fuel aggregate is accommodated in each cell of the basket inserted into the cavity.
2. The cask according to claim 1, wherein a part of the inside of the cavity is matched with the external shape of the basket.
3. A cask having a structure that the shape of either one of the inner surface of a cavity of a shell main body that has a neutron shielding unit at its outer periphery and shields the  $\gamma$ -rays and the outer surface of a basket that has latticed cells structured by a plurality of angular pipes having neutron absorbing property, is matched with the shape of the other, whereby each used nuclear fuel aggregate is accommodated in each cell of the basket inserted into the cavity.

4. The cask according to any one of claims 1 to 3, wherein dummy pipes are further provided, and the shape of a portion within the cavity that has room in the thickness of the shell main body is matched with the shape of the dummy pipes, whereby  
5 the dummy pipes are inserted into the cavity together with the basket in a state that the dummy pipes are in contact with the angular pipes.

5. The cask according to any one of claims 1 to 4, wherein  
10 auxiliary shielding units for shielding the  $\gamma$ -rays are further provided at portions of the outermost side of the shell main body that has a small thickness of the shell main body.

15 6. A cask having a structure that spacers are provided between a cavity of a shell main body that has a neutron shielding unit at its outer periphery and shields the  $\gamma$ -rays and a basket that has latticed cells structured by a plurality of angular pipes having neutron absorbing property, whereby  
20 each used nuclear fuel aggregate is accommodated in each cell of the basket inserted into the cavity.

7. The cask according to any one of claims 1 to 6, wherein a plurality of angular pipes that constitute the basket are  
25 integrated together before they are inserted into the cavity.

8. A cask comprising:

a basket having a plurality of latticed cells formed for accommodating used nuclear fuel aggregates, by bundling a plurality of angular pipes having neutron absorbing material added to a structural material;

a shell main body having a cylindrical cavity that has been forged from a  $\gamma$ -rays shielding material, and that is plane processed by matching the shape of the inside of this cavity with the external shape of the basket constructed of the angular pipes; and

a neutron shielding unit having a plurality of internal fins extended between the shell main body and an external cylinder, and for shielding neutrons filled in a space formed by the shell main body, the external cylinder and the internal fins, wherein

the angular pipe are sequentially inserted into the cavity to structure the basket while bringing the outer surface of the basket into contact with the inner surface of the cavity.

20

9. A cask having a structure that the shape of the inside of a cavity of a shell main body that has a neutron shielding unit at its outer periphery and shields the  $\gamma$ -rays is matched with the external shape of a basket that has a latticed angular cross-sectional shape by alternately combining in an

25

orthogonal direction a plurality of plates having neutron absorbing property, whereby each used nuclear fuel aggregate is accommodated in each cell of the basket inserted into the cavity.

5

10. The cask according to claim 9, wherein a part of the inside of the cavity is matched with the external shape of the basket.

10 11. The cask according to claim 9 or 10, wherein dummy pipes are further provided, and the shape of a portion within the cavity that has room in the thickness of the shell main body is matched with the shape of the dummy pipes, whereby the dummy pipes are inserted into the cavity together with  
15 the basket in a state that the dummy pipes are in contact with the plates.

12. The cask according to any one of claims 9 to 11, wherein when the basket is constructed by combining the plates, a  
20 thermal conductive plate having a contact with the cavity wall is provided at the end of each plate positioned at the outer periphery of the basket.

13. The cask according to any one of claims 9 to 11, wherein  
when the basket is constructed by combining the plates, a  
thermal conductive plate is provided between the end of each  
plate positioned at the outer periphery of the basket and  
5 the end of the other plate.



## ABSTRACT

Resin (106) for shielding neutrons is provided at the outer periphery of a shell main body (101) that shields the  $\gamma$ -rays. Basket (130) is constructed of a plurality of angular pipes (132) having neutron absorbing property. The  
5 inside of a cavity (102) of the shell main body (101) is processed to match its shape with the external shape of the basket (130), and the angular pipes (132) are inserted into this cavity (102) to be brought into contact with the inner  
10 surface of the cavity (102). Used nuclear fuel aggregates are accommodated and stored in latticed cells structured by the angular pipes (132). Thermal conductivity of decay heat generated from the used nuclear fuel aggregates is improved as the outer surface of the angular pipes (132)  
15 and the inner surface of the cavity (102) are in indirect contact with each other.

1/20

FIG. 1

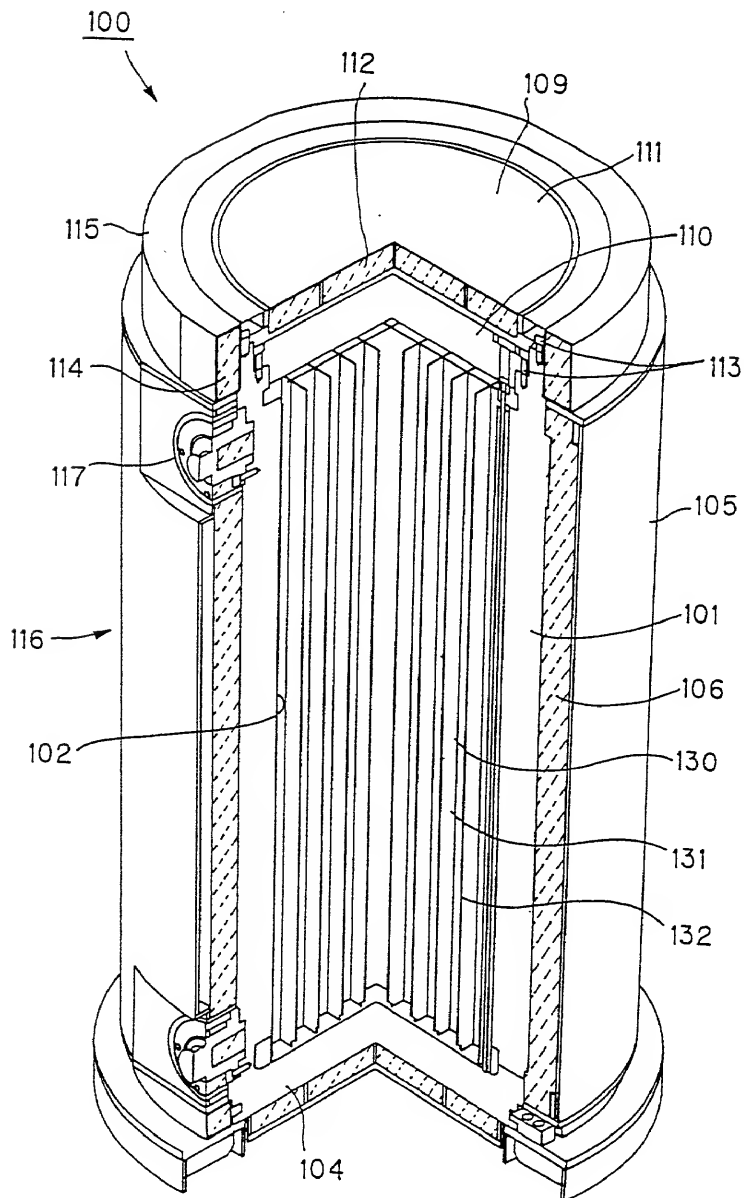
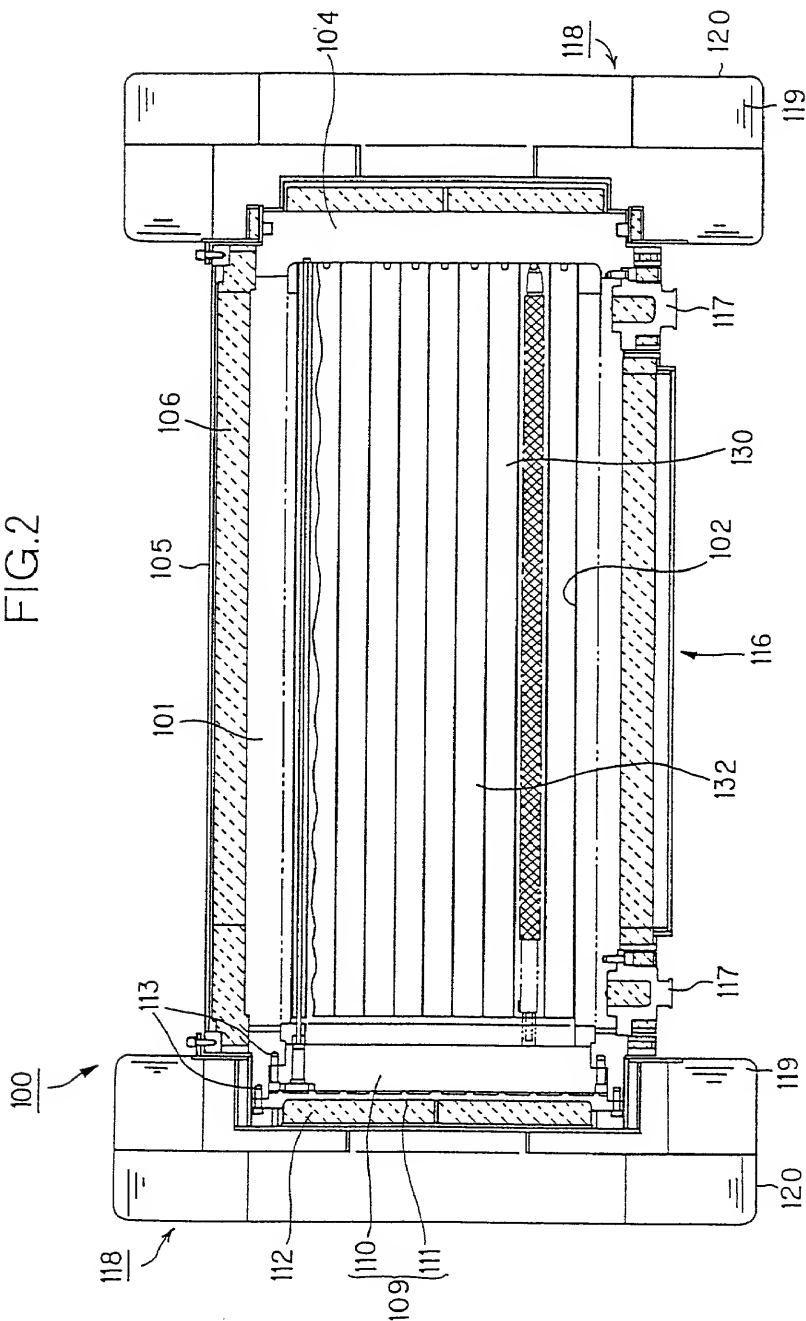
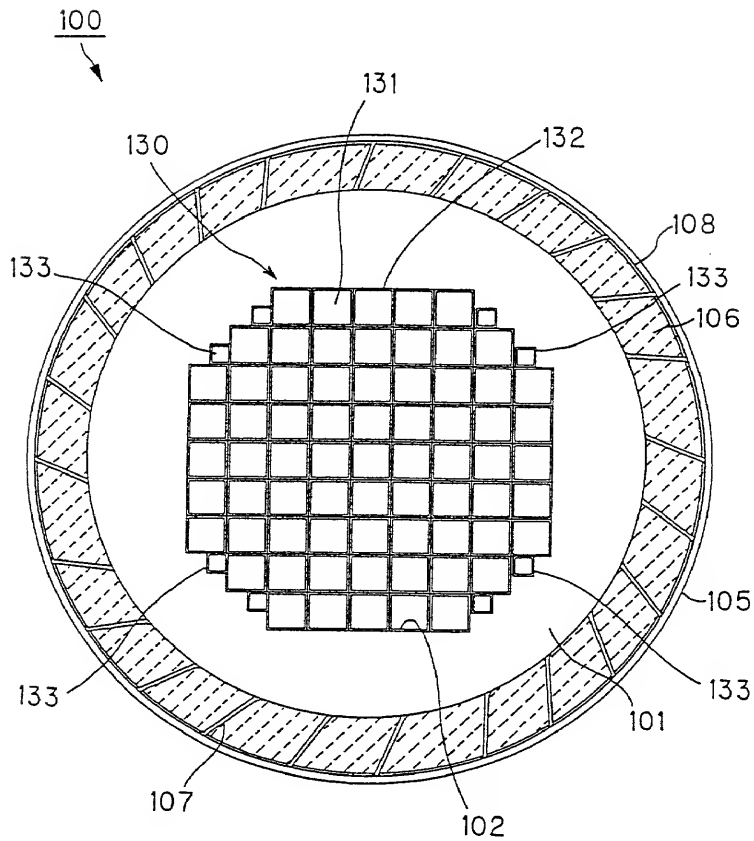


FIG. 2



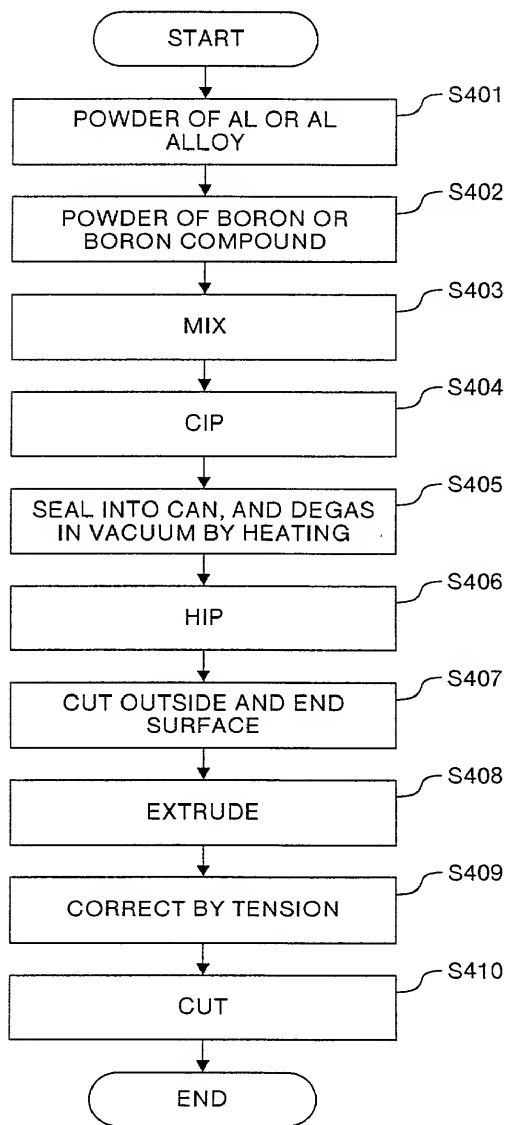
3 / 2 0

FIG.3



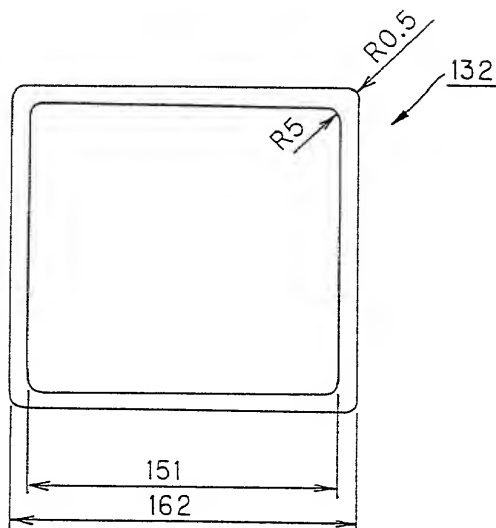
4/20

FIG.4



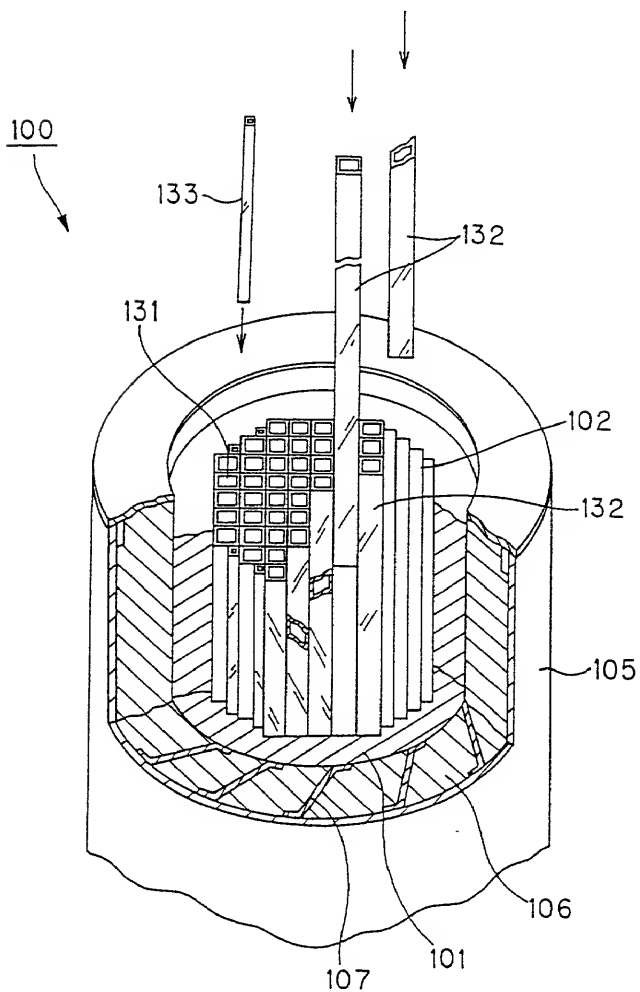
5/20

FIG.5



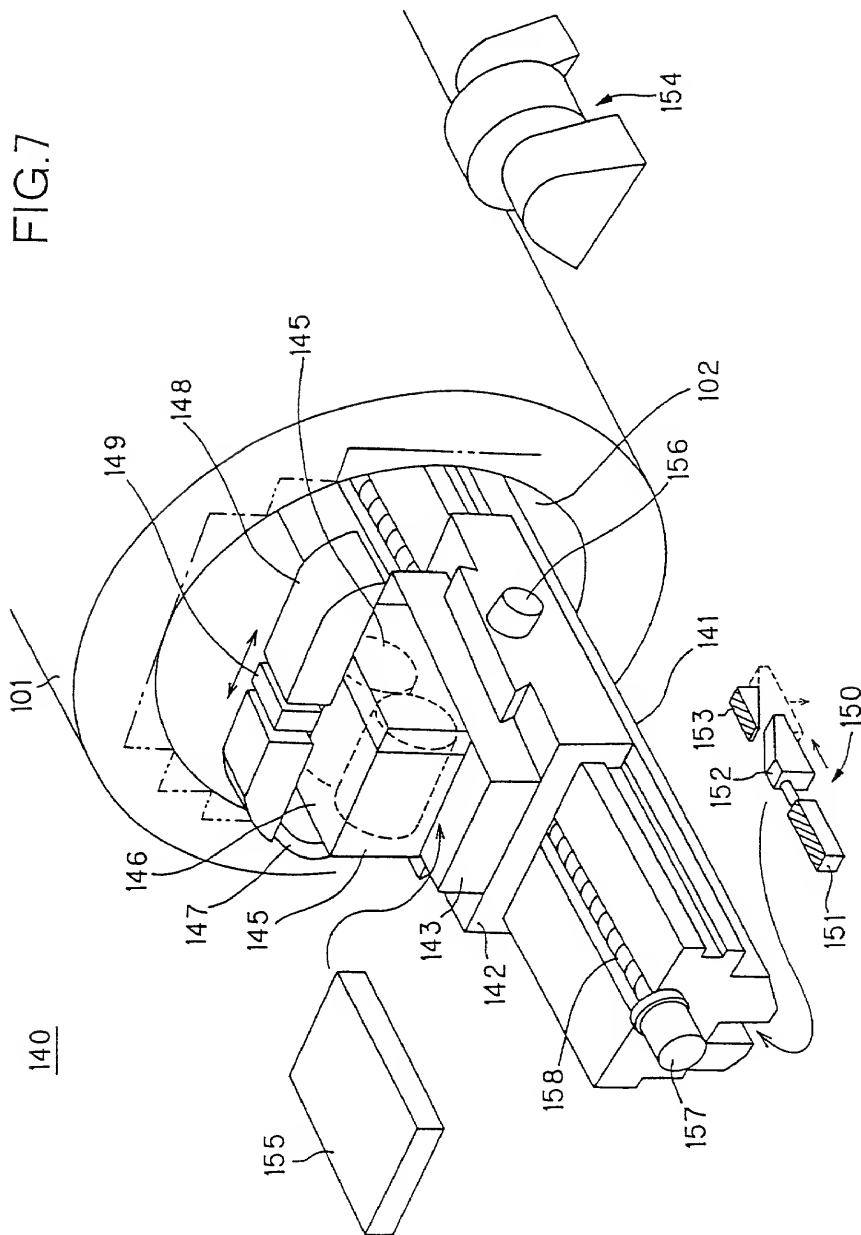
6/20

FIG. 6



7/20

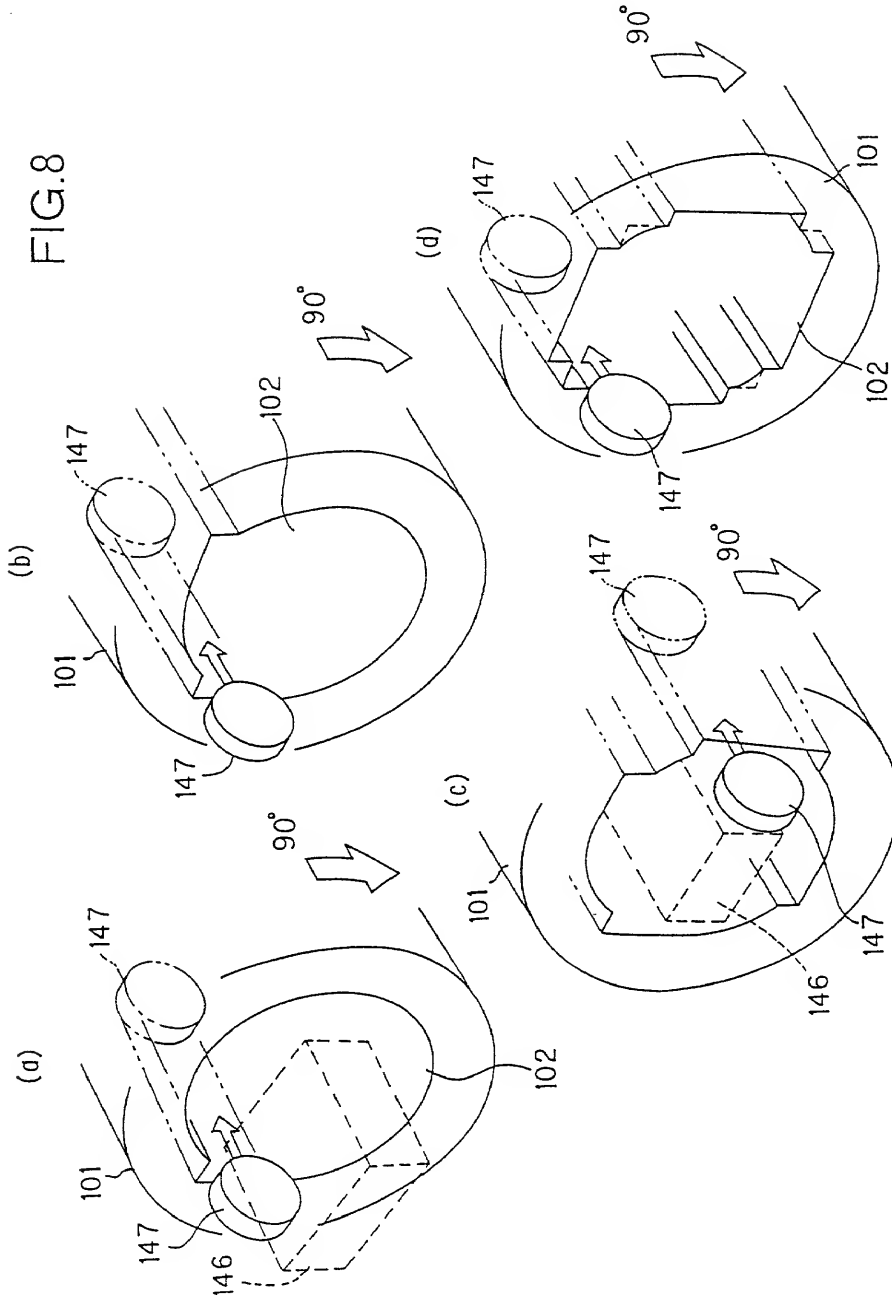
FIG. 7





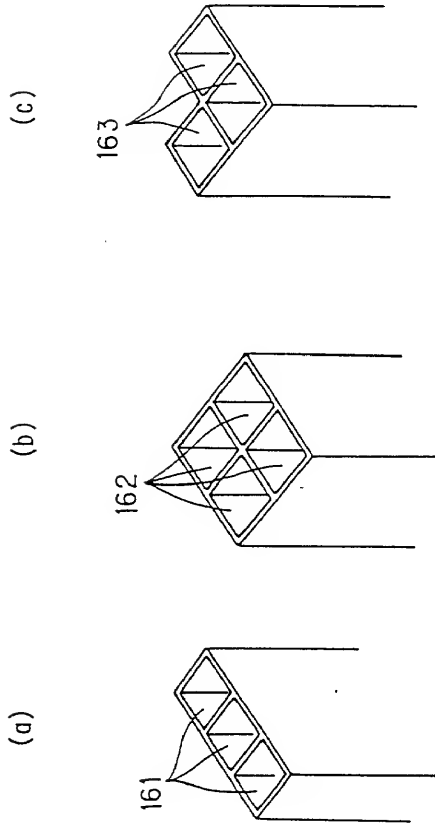
8/20

FIG. 8



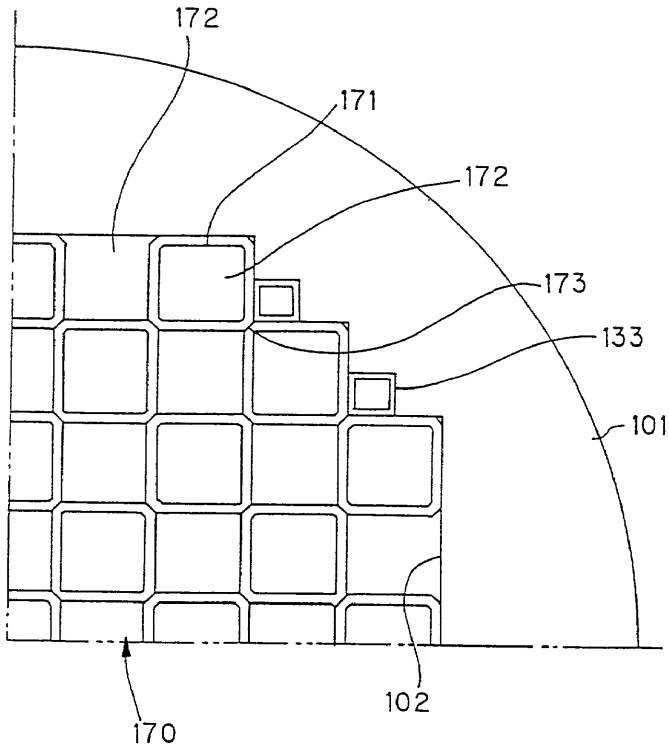
9/20

FIG. 9



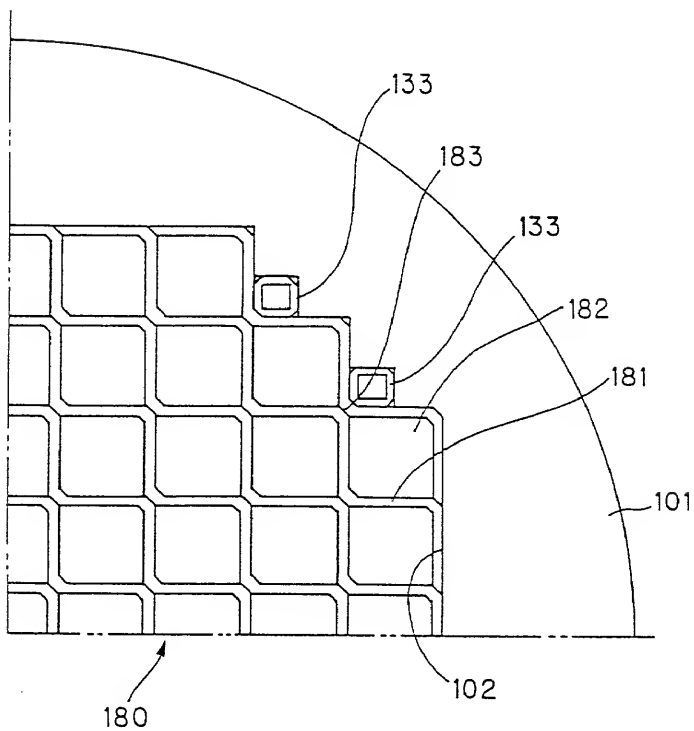
10/20

FIG.10



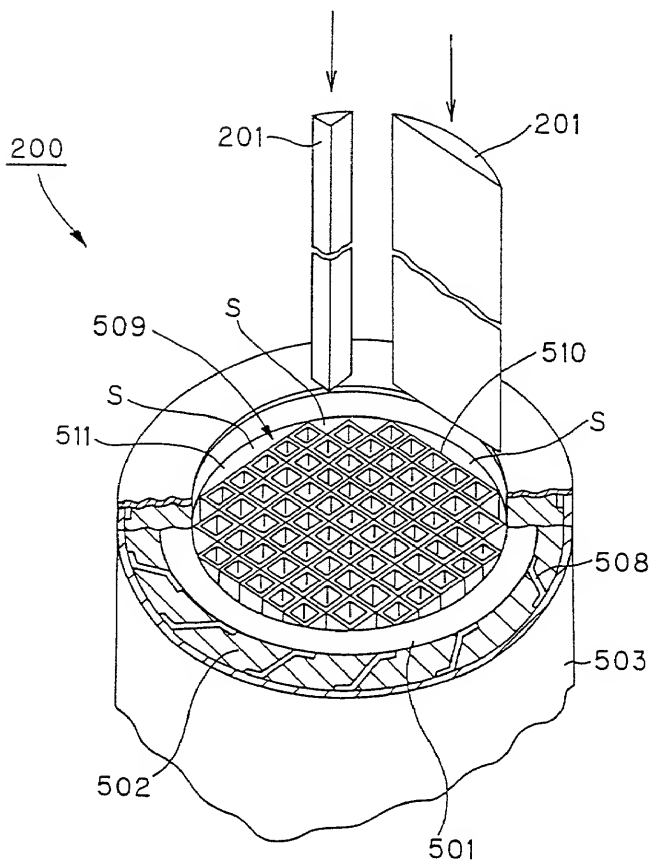
11/20

FIG.11



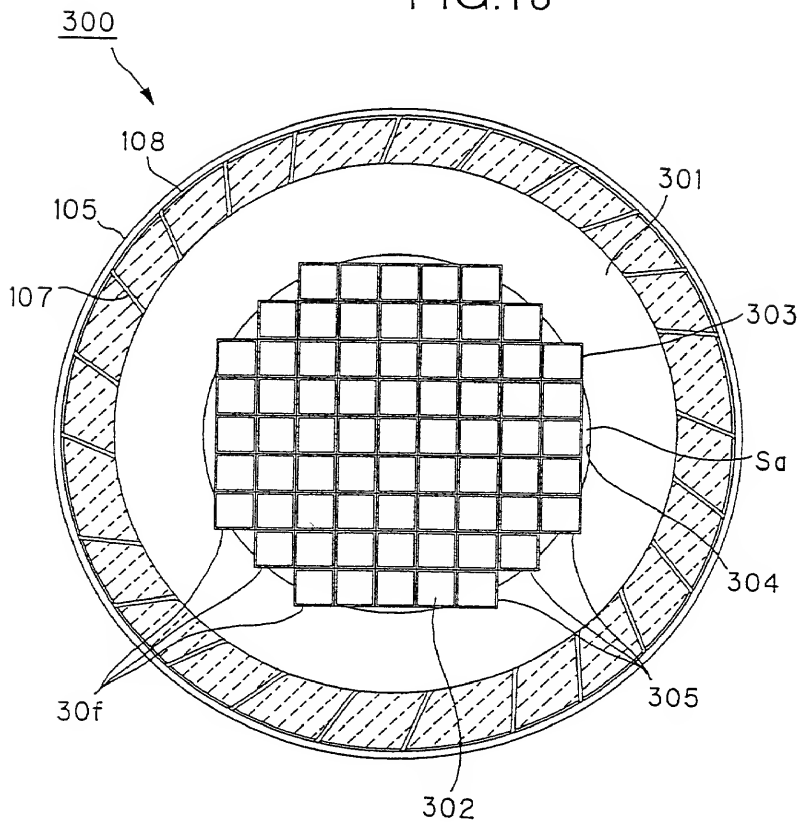
12/20

FIG.12



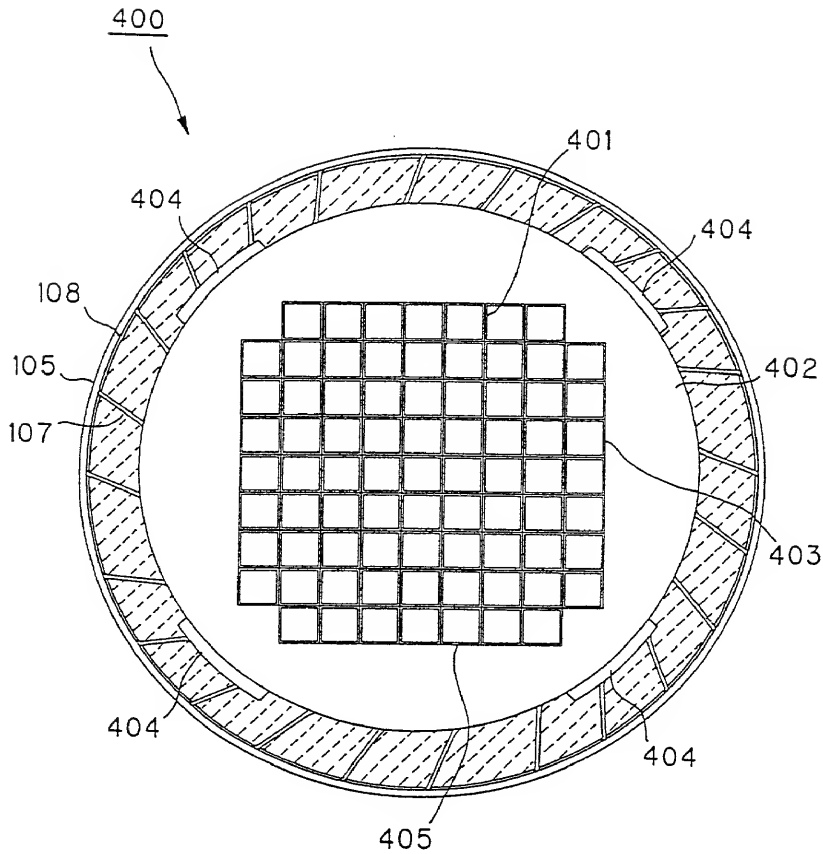
13/20

FIG.13



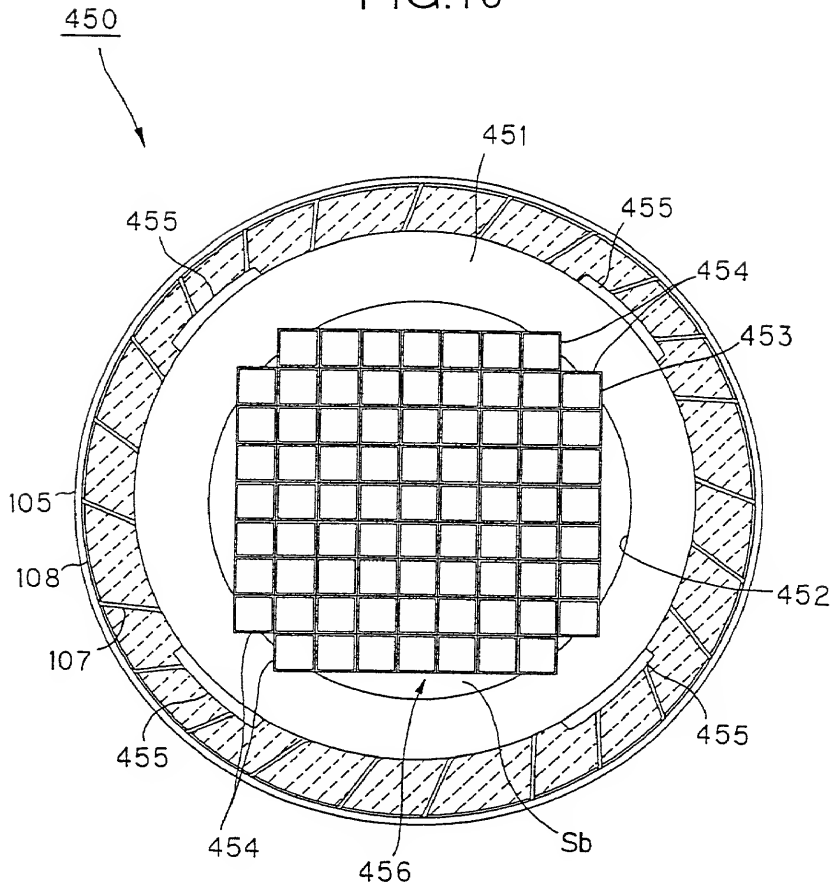
14/20

FIG.14



15/20

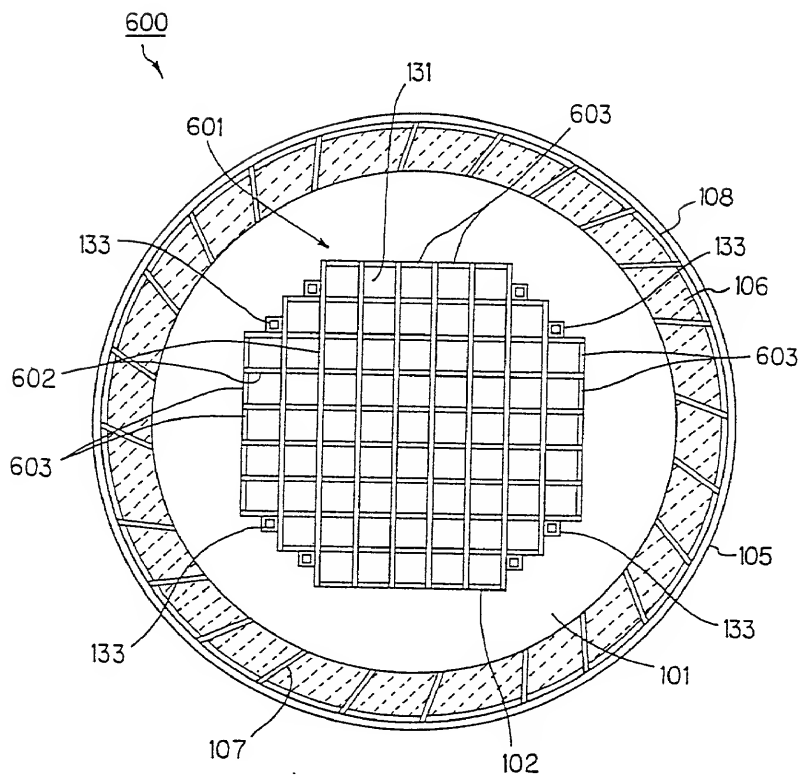
FIG.15





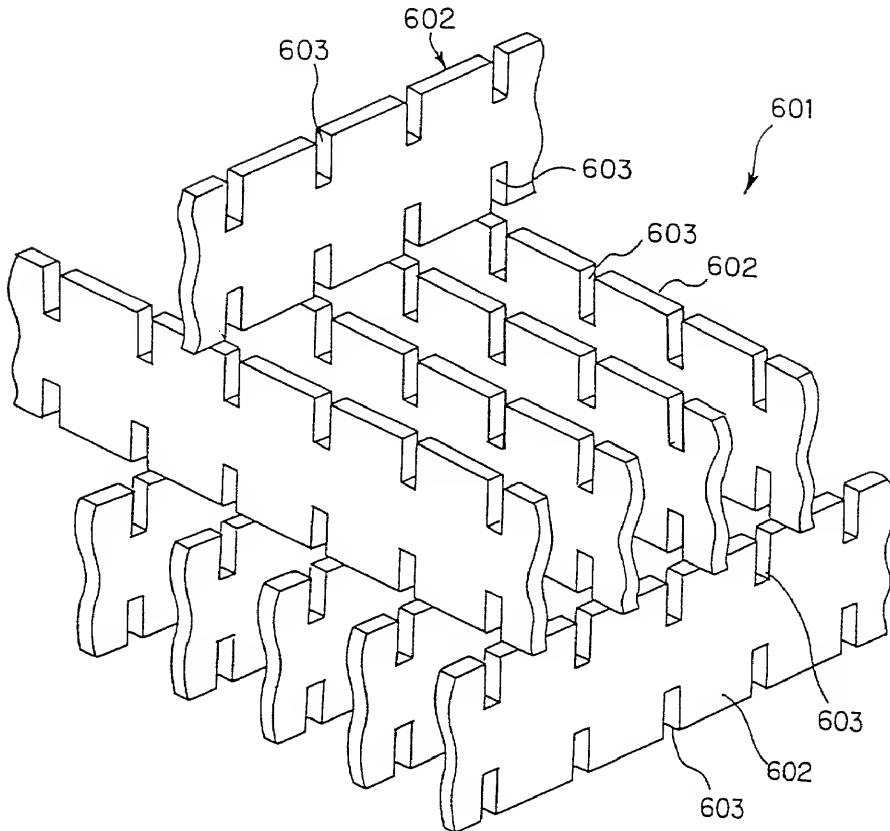
16/20

FIG.16



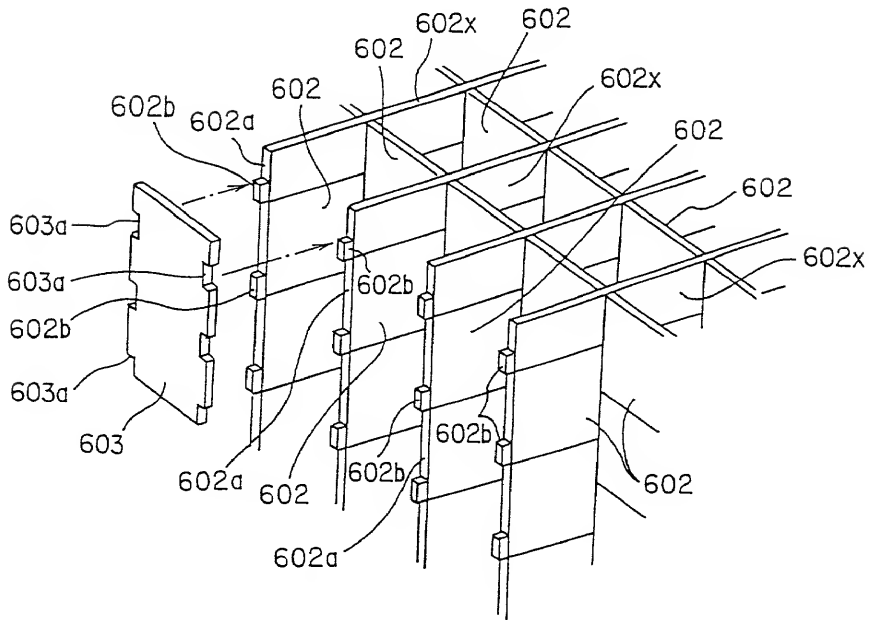
17/20

FIG.17

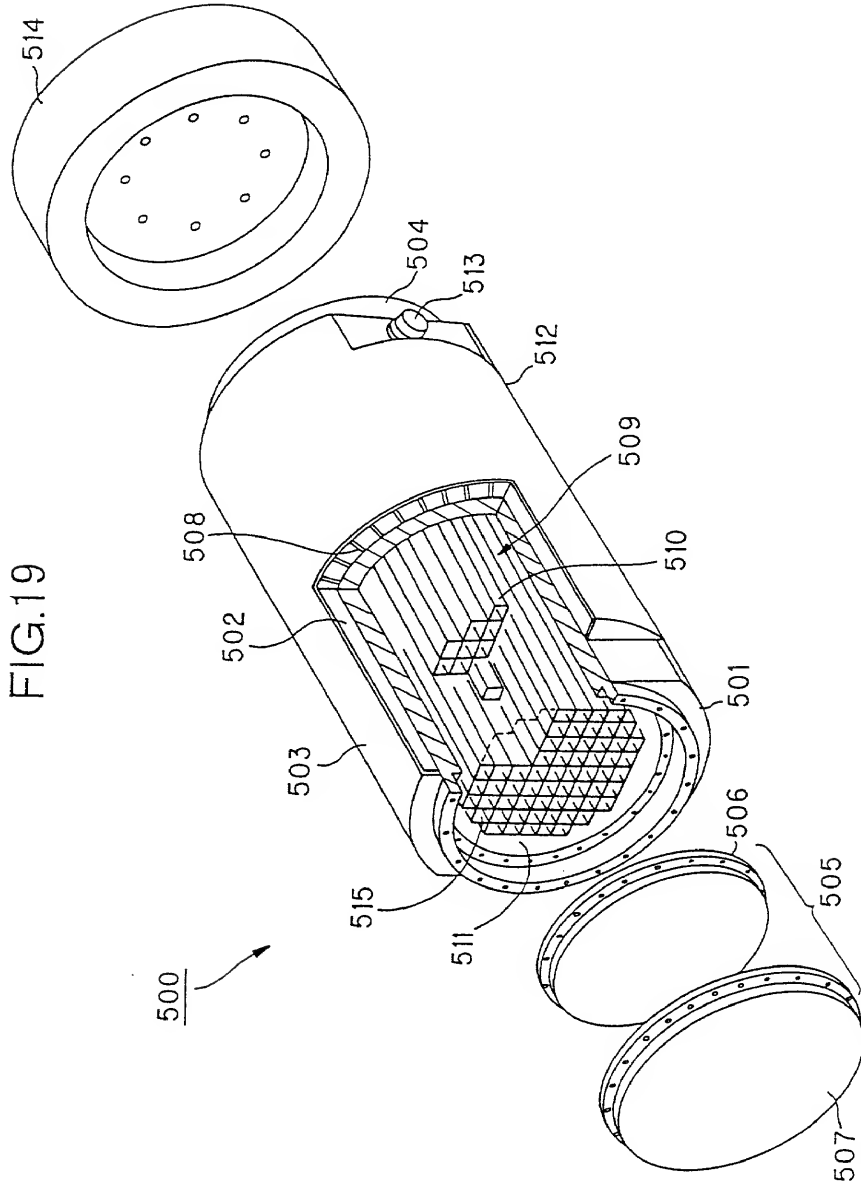


18/20

FIG.18

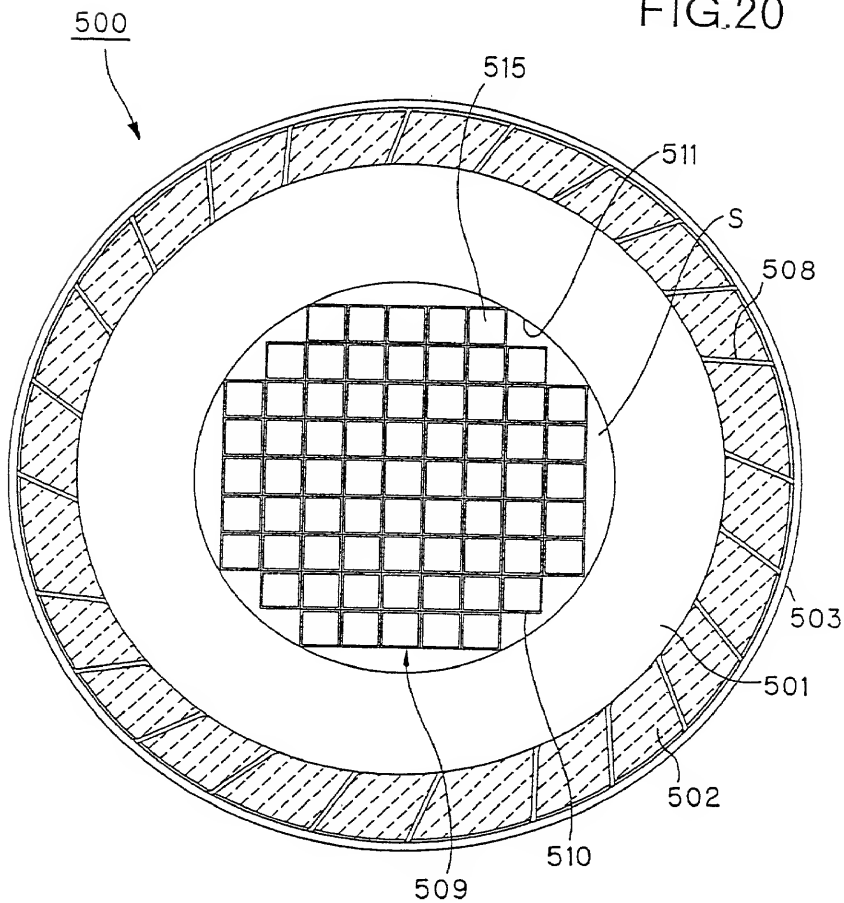


19/20



20/20

FIG. 20



# Declaration and Power of Attorney For Patent Application

## 特許出願宣言書及び委任状

### Japanese Language Declaration

#### 日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者（下記の名称が複数の場合）であると信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled.

CASK

上記発明の明細書は、

the specification of which

☒ 本書に添付されています。

☒ is attached hereto.

☐ \_\_\_\_月\_\_\_\_日に提出され、米国出願番号または特許協定条約国際出願番号を\_\_\_\_とし、  
(該当する場合) \_\_\_\_に訂正されました。

☐ was filed on \_\_\_\_\_  
as United States Application Number or  
PCT International Application Number  
\_\_\_\_\_ and was amended on  
\_\_\_\_\_ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

## Japanese Language Declaration

(日本語宣言書)

私は、米国法典第35編119条 (a) - (d) 項又は365条 (b) 項に基づき下記の、米国以外の国の少なくとも一カ国を指定している特許協力条約365 (a) 項に基づく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

Prior Foreign Application(s)

外国での先行出願

11-249314

Japan

(Number)  
(番号)(Country)  
(国名)(Number)  
(番号)(Country)  
(国名)

私は、第35編米国法典119条 (e) 項に基づいて下記の米国特許出願規定に記載された権利をここに主張いたします。

(Application No.)  
(出願番号)(Filing Date)  
(出願日)

私は、下記の米国法典第35編120条に基づいて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約365条 (c) に基づく権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第35編112条第1項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第37編1条56項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

(Application No.)  
(出願番号)(Filing Date)  
(出願日)(Application No.)  
(出願番号)(Filing Date)  
(出願日)

私は、私自信の知識に基づいて本宣言書中で私が行なう表明が真実であり、かつ私の入手した情報と私の信じているところに基づく表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第18編第1001条に基づき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行なえば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Priority Claimed  
優先権主張

2/Sep./1999

(Day/Month/Year Filed)  
(出願年月日)Yes  
はいNo  
いいえ(Day/Month/Year Filed)  
(出願年月日)Yes  
はいNo  
いいえ

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.)  
(出願番号)(Filing Date)  
(出願日)

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of application.

(Status: Patented, Pending, Abandoned)  
(現況: 特許許可済、係属中、放棄済)(Status: Patented, Pending, Abandoned)  
(現況: 特許許可済、係属中、放棄済)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

## Japanese Language Declaration

(日本語宣言書)

委任状：私は下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。  
(弁理士、または代理人の指名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: (list name and registration number)

Norman F. Oblon, Registration Number 24,618; Marvin J. Spivak, Registration Number 24,913; C. Irvin McClelland, Registration Number 21,124; Gregory J. Maier, Registration Number 25,599; Arthur I. Neustadt, Registration Number 24,854; Richard D. Kelly, Registration Number 27,757; James D. Hamilton, Registration Number 28,421; Eckhard H. Kuesters, Registration Number 28,870; Robert T. Pous, Registration Number 29,099; Charles L. Gholz, Registration Number 26,395; Vincent J. Sunderdick, Registration Number 29,004; William E. Beaumont, Registration Number 30,996; Steven B. Kelber, Registration Number 30,073; Robert F. Gnuse, Registration Number 27,295; Jean-Paul Lavalleye, Registration Number 31,451; Stephen G. Baxter, Registration Number 32,884; Martin M. Zolick, Registration Number 35,745; Robert W. Hahl, Registration Number 33,893; Richard L. Treanor, Registration Number 36,379; Steven P. Weikrouch, Registration Number 32,829; John T. Goolkasian, Registration Number 26,142; Marc R. Labgold, Registration Number 34,651; William J. Healey, Registration Number 36,160; Richard L. Chinn, Registration Number 34,305; Steven E. Lipman, Registration Number 30,011; Carl E. Schiler, Registration Number 34,426; James J. Kulbaski, Registration Number 34,648; Catherine B. Richardson, Registration Number 39,007; Richard A. Neifeld, Registration Number 35,299; and J. Derek Mason, Registration Number 35,270; with full powers of substitution and revocation.

書類送付先

Send Correspondence to:

OBLON, SPIVAK, MCCLELLAND, MAIER & NEUSTADT, P.C.  
FOURTH FLOOR  
1755 JEFFERSON DAVIS HIGHWAY  
ARLINGTON, VIRGINIA 22202 U.S.A.

直接電話連絡先: (名前及び電話番号)

Direct Telephone Calls to: (name and telephone number)

(703) 413-3000

唯一または第一発明者名		Full name of sole or first inventor Katunari OHSONO	
発明者の署名	日付	Inventor's signature <i>Katunari Ohson</i>	Date Apr. 16, 2001
住所		Residence Hyogo, Japan <i>SPX</i>	
国籍		Citizenship Japanese	
私書箱		Post Office Address c/o KOBE Shipyard & Machinery Works, MITSUBISHI HEAVY INDUSTRIES, LTD.	
		1-1, Wadasaki-cho 1-chome, Hyogo-ku, Kobe, Hyogo-ken 652-8585 Japan	
第二共同発明者		Full name of second joint inventor, if any Kouiti UE	
第二共同発明者の署名	日付	Second Inventor's signature <i>Kouiti Ue</i>	Date Apr. 16, 2001
住所		Residence Hyogo, Japan <i>SPX</i>	
国籍		Citizenship Japanese	
私書箱		Post Office Address c/o KOBE Shipyard & Machinery Works, MITSUBISHI HEAVY INDUSTRIES, LTD.	
		1-1, Wadasaki-cho 1-chome, Hyogo-ku, Kobe, Hyogo-ken 652-8585 Japan	

(第三以降の共同発明者についても同様に記載し、署名すること)

(Supply similar information and signature for third and subsequent joint inventors.)



## Japanese Language Declaration

30		Full name of third joint inventor, if any Toshihiro MATSUOKA	
日付		Third Inventor's signature T. Matsuoka	Date Apr. 16, 2001
住所	Residence Hyogo, Japan SX		
国籍	Citizenship Japanese		
郵便の宛先	Post Office Address c/o KOBE Shipyard & Machinery Works, MITSUBISHI HEAVY INDUSTRIES, LTD. 1-1, Wadasaki-cho 1-chome, Hyogo-ku, Kobe, Hyogo-ken 652-8585 Japan		

		Full name of fourth joint inventor, if any	
日付		Fourth Inventor's signature	Date
住所	Residence		
国籍	Citizenship		
郵便の宛先	Post Office Address		

		Full name of fifth joint inventor, if any	
日付		Fifth Inventor's signature	Date
住所	Residence		
国籍	Citizenship		
郵便の宛先	Post Office Address		

		Sixth Inventor's signature		Date
日付		Full name of sixth joint inventor, if any		
住所	Residence			
国籍	Citizenship			
郵便の宛先	Post Office Address			

(第六またはそれ以降の共同発明者に対しても同様な情報および署名を提供すること。)

(Supply similar information and signature for third and subsequent joint inventors.)